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Science Bulletin

THE MYOLOGY OF *SCELOPORUS C. CLARKI* BAIRD AND GIRARD (REPTILIA: IGUANIDAE)

by

D. M. Secoy

BIOLOGICAL SERIES — VOLUME XIV, NUMBER 1

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TABLE OF CONTENTS

MATERIALS AND METHODS 1
INTRODUCTION 2
MYOLOGY 3
DISCUSSION 10
CONCLUSIONS 21
LITERATURE CITED 21

THE MYOLOGY OF *SCELOPORUS C. CLARKI* BAIRD AND GIRARD (REPTILIA: IGUANIDAE)

by

D. M. Secoy[1]

ABSTRACT

Examination of the complete musculature of *Sceloporus clarki clarki* Baird and Girard and seven other species of *Sceloporus* revealed variation among species of *Sceloporus* and between *Sceloporus* and other iguanid lizards. The muscles in which the greatest variation was found were the internandibularis group, the constrictor colli, the episterno-cleido-mastoideus, the episternohyoideus, the coracoid head of the triceps, the costocoracoid and the flexor tibialis externus. This study indicates: (1) *Sceloporus* is more closely allied to *Crotaphytus* than to the ground-dwelling iguanines; (2) the possibility of the basal stock of *Sceloporus* being arboreal, and, (3) *Sceloporus* is a genus in the process of rapid differentiation.

INTRODUCTION

Even a cursory glance at the literature dealing with the morphology of the suborder Lacertilia reveals the scarcity and scattered nature of studies concerned with the soft anatomy.

The myology of the entire body has been described in varying detail in eight genera of the suborder Lacertilia: *Iguana* (Mivart, 1867), *Chamaeleon* (Mivart, 1870),*Platydactylus* (Sanders, 1870), *Liolepis* (Sanders, 1872), *Phrynosoma* (Sanders, 1874), *Pseudopus* (Humphry, 1872), *Chlamydosaurus* (de Vis, 1883), and *Uromastix* (George, 1948) have been examined and described. Laboratory dissection guides showing the antomy of *Crotaphytus* (Davis, 1934) and *Agama* (Harris, 1963) are brief.

A search of the literature for descriptions of portions of the anatomy of a genus, or comparative works examining representatives of different genera or families is much more rewarding. The former includes the recent work by Oelrich (1956) on the head of *Ctenosaura pectinata*, Avery and Tanner's paper (1964) on the head and thorax of *Sauromalus*, Robison and Tanner's paper (1962) on the anterior region of *Crotaphytus* and *Gambelia*, and Jenkins and Tanner's paper (1968) on *Phrynosoma*.

Comparative studies have been divided into three main groups: those concerned with the muscles of the jaw articulation; those which have examined the variation in the muscles connected with the hyoid apparatus; and those head of reptiles, as is the case with other vertebrate groups, has been studied most extensively. The works on the jaw muscles include those of Versluys (1904), Bradley (1903), Adams (1919), Lakjer (1926), and Haas (1960). Some of the more important works on the hyoid apparatus are those by Zavattari (1908), Gandolfi (1908), and Gnanamuthu (1936). Edgeworth's treatise (1935) on cranial muscles includes all head musculature and discusses the homologies of structures extensively, although Brock (1938) disagrees with his ideas of muscle origins. Camp (1923) has used the numerous generic descriptions of the hyoid and its associated musculature in the construction of his lizard classification.

The other area of intensive interest and work has been in limb musculature. Romer (1922, 1923, 1942) has established homologies in the pelvic limb muscles among the several reptilian groups based on his research and that of Gadow (1882). Haines (1934, 1935) and Appleton (1928) have also discussed the homologies of the pelvic and thigh muscles. The anterior limb and pectoral girdle have been studied by Fürbringer (1876), Romer (1924, 1944), McMurrich (1903, 1903a), and Howell (1938).

Since its description by Wiegmann in 1828 *Sceloporus* has been one of the most intensively studied of the New World iguanid lizards. The

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large size of the genus and its broad distribution concerned with the muscles of the limbs. The have made it ideal for studies on taxonomy and distribution. The same two factors have made it unwieldy and a deterrent to those who wish to study the entire genus.

Early studies of the genus include those of Dumeril and Bibron (1837), Boulenger (1897), and Cope (1900). The definitive work on the genus is that of Hobart Smith (1936, 1937, 1937a, 1938, 1939). These studies have been based on external characteristics and the only mention of skeletal or soft anatomy is at the generic level.

The osteology of the genus has been described piecemeal, usually in conjunction with that of other reptiles. Cope (1892) gives a complete description of the skull and skeleton but gives no figures. Camp (1923), in his work on lizard classification, refers to *Sceloporus* in the discussion of many of the skeletal characters. Stokely (1950) mentions the possibility of the occurrence of an intermedium in *Sceloporus*. Hotton (1955) discusses the dentition of *Sceloporus graciosus, S. magister* and *S. undulatus* in relation to their prey choice. Romer (1956) illustrates various skeletal elements in his treatise on reptilian osteology. Lundelius (1957) made a statistical analysis of the skeletal adaptations of *Sceloporus olivaceus* and *S. undulatus hyacinthinus* in relation to their environments. Jollie (1960) included *Sceloporus undulatus* in his analysis of the lizard skull. Avery and Tanner (1964) illustrated and discussed the variation in the wrist bones of several genera of iguanids, including *Sceloporus*. Etheridge (1964, 1965, 1967) discussed and illustrated several skeletal elements of *Sceloporus* in his studies of skeletal variation within the Iguanidae. Miller (1966) discussed *Sceloporus* in his work on the cochlear duct in the Lacertilia.

The myology has been less well studied. Camp (1923) mentions the genus in his discussion of the rectus abdominis and the mandibulohyoideus (his genio-hyoideus). Avery and Tanner (1964) use a specimen of *Sceloporus magister* for comparison with *Sauromalus*. Snyder (1962) illustrated the hind leg of *Sceloporus* in his discussion of muscle grouping and development in relation to lizard bipedalism. In his paper on the anatomical ratios of lizard limbs, Snyder (1954) used *Sceloporus* as an example of persistent quadrupedality.

The paucity of information on the muscular anatomy of one of the largest genera of New World lizards was the impetus for this study. The primary concern of the study was the description of the myology of the entire body of *Sceloporus clarki*. Comparative dissections of other species of *Sceloporus* were made. Comparisons were also made with descriptions of the myology of other iguanids.

I wish to thank Dr. Hugo Rodeck, director, and Dr. T. Paul Maslin, curator of zoology, of the Museum of the University of Colorado for permission to dissect specimens from the herpetologieal collections. Funds for the collection of specimens were provided by the Kathy Liehty Fund and Grant #GB 2362, National Science Foundation made to Dr. T. Paul Maslin. The figures were drawn by Miss Susan George.

This manuscript has been reviewed by Drs. W. W. Tanner, H. M. Smith, and D. F. Avery. Their comments and suggestions are greatly appreciated.

MATERIALS AND METHODS

The species used for the basic dissections was *Sceloporus c. clarki* Baird and Girard. Sufficient specimens were dissected to note variation found within a species. *Sceloporus magister*, a closely related species (Lowe, Cole and Patton, 1967), was selected for comparative purposes. The phylogenetic tree postulated by Smith (1939) was used to select several other species of *Sceloporus* for comparative examination. These species were used to determine at what level of consanguinity, anatomical differences, if any, occurred.

Speciment of *Sceloporus c. clarki* examined were UCM 13289, 34095, 34099, 34183, 34184, 34185, 34202, 34215, 34216, 34217, 34218, 34157, 34158, 34159, 35160, 34179, 34180. Five unregistered specimens were also dissected.

Specimens of other species of *Sceloporus* used for comparative purposes were *Sceloporus magister* Hallowell UCM 30178; *Sceloporus poinsetti* Baird and Girard UCM 34132; *Sceloporus v. variabilis* Wiegmann UCM 28778, 28782; *Sceloporus malachiticus smargadinus* Boucourt UCM 24523, 24525; *Sceloporus undulatus erythrocheilus* Maslin UCM 17414, 17442; *Sceloporus grammicus disparilis* Stejneger UCM 20034; *Sceloporus chrysostictus* Cope UCM 16511, 16548.

All specimens had been fixed in 10% formalin and stored in 70% ethanol.

Myology

The basic description following the muscle name is that of the condition found in *Sceloporus clarki*. Any deviation from this condition which was found in other species of *Sceloporus* dissected is then noted. Comparisons were then made with the published descriptions and illustrations of other iguanid lizards. The genera used for comparison were *Iguana* (Mivart, 1867; Romer, 1922; Haines, 1934, 1936; Howell, 1936, 1938; and Evans, 1939), *Phrynosoma* (Sanders, 1874; Jenkins and Tanner, 1968), *Ctenosaura* (Oelrich, 1956), *Sauromalus* (Avery and Tanner, 1964) and *Crotaphytus* (Robison and Tanner, 1962). Only those muscles which varied within the genus *Sceloporus* or between *Sceloporus* and other iguanids are included in the present account.

Muscle nomenclature used here is based primarily on that of Romer for the body musculature and Edgeworth for the musculature of the head.

Throat and Hyoid Musculature

Depressor palpebrae inferioris

Origin: from the floor of the orbit.

Insertion: into the whole of the lower eyelid.

This is an extremely thin and diffuse set of fibers found in the lower eyelid. No levator palpebrae superioris was found. Of the other studies, this muscle was noted only in *Ctenosaura*.

Intermandibularis

This is a thin sheet of muscle which lies on the ventral aspect of the lower jaw over the hyoid musculature. A varying number of fibers insert into the skin of the gular region. The muscle is divided into an anterior and posterior portion. The anterior portion is designated the intermandibularis anterior profundus, since it appears to be homologous to the deep portion of the intermandibularis anterior in those genera in which the intermandibularis has three slips. The fibers of this muscle lie perpendicular to the long axis of the body.

Intermandibularis anterior profundus

Origin: from the medial side of each dentary.

Insertion: into the midventral fascia.

In this genus the only differentiation between the anterior and posterior slips of the intermandibularis is the unmasked origin of the anterior profundus from the ramus. Its origin lies between that of the mandibulohyoideus and the genioglossus.

The intermandibularis anterior superficialis is not present in any species of *Sceloporus* examined. A narrow band of this muscle is present in *Crotaphytus, Sauromalus* and *Ctenosaura*. In *Phrynosoma*, the muscle appears to be fairly broadly developed.

Intermandibularis posterior

Origin: from the latero-ventral to lateral surface of the posterior half of the mandible.

Insertion: into the midventral fascia.

The anterior portion of the muscle comes to the surface of the throat by a varying number (3-7, usually 5-6) of slips which interdigitate with the mandibulohyoideus 1. The number of interdigitations is usually asymmetrical for an individual. The posterior portion comes from the lateral surface of the jaw, from the fascia covering the pterygomandibularis and also directly by a tendon from the lateral surface of the ramus between the pterygomandibularis and the insertion of the depressor mandibularis. In many specimens the muscle is composed only of fascia in the center so that the body of the hyoid and the base of the lingual process are visible through the fascia. This window of fascia occurs at the posterior boundary of the intermandibularis posterior. The fibers of the constrictor colli go to the midline just posterior to the window. In cases where this window was not present, it was very difficult to differentiate this muscle from the constrictor colli.

In the specimen of *magister* examined in the course of the dissection the intermandibularis posterior and constrictor colli appeared as one sheet of muscle. There also was no great division between the two portions of the intermandibularis. Avery and Tanner (1964, p. 15) state that the specimen of *magister* which they examined had a broad separation between the two portions of the intermandibularis. In *variabilis* the intermandibularis posterior was very thin and composed of fascia over the entire ventral surface of the jaw while the anterior portion was very well developed and several fibers thick. In *grammicus* there was a window of fascia over the hyoid body. In *poinsetti* the posterior was thinly developed while the anterior was heavily developed. In *chrysostictus* there was no differentiation between the posterior and the constrictor colli. This is also the case in *undulatus*.

In *Crotaphytus* it was stated (Robison and Tanner, 1962) that the anterior profundis and posterior portions were not easily separated except by origin as in *Sceloporus*. But, the constrictor colli was separated from the posterior margin of the intermandibularis posterior by a

band of fascia. There are three or four interdigitations of the posterior section with the mandibulohyoideus I. In *Sauromalus* the posterior is a narrow band of muscle which is separated from both the anterior section of the muscle and the constrictor colli by bands of fascia. In *Ctenosoura* the posterior section is broad and in contact with the constrictor colli. In *Iguana* the intermandibularis is heavily developed in conjunction with the dewlap. In *Phrynosoma* the intermandibularis group is well developed, but Sanders mentions no interdigitations of the posterior with the mandibulohyoideus I.

Constrictor colli

Origin: from the cervical portion of the dorsal aponeurosis.

Insertion: into the midventral fascia.

This is the thin sheet of muscle which covers the side of the neck and the posterior portion of the throat and hyoid. It is superficial to the depressor mandibulae group, the omohyoid, episterno-cleido-mastoid, episternohyoid and the deep neck muscles. The muscle is usually so broadly developed as to cover part of the temporal fossa. Some *clarki* specimens had fibers inserting into the surface fascia of the episternohyoid superficialis.

In *poinsetti* the constrictor colli was broadly developed but became tendinous before reaching the midline. In *undulatus* the constrictor colli was connected to the episternohyoideus but was not as broad as in *clarki*. In *variabilis*, *malachiticus*, and *grammicus*, it was present only as a narrow band across the throat, widely separated from the intermandibularis posterior, and covering only a portion of the omohyoid and episternohyoideus superficialis.

The constrictor colli is present as a narrow band also in *Phrynosoma*, *Crotaphytus*, *Sauromalus*, and *Ctenosaura*. In *Iguana* it is more heavily developed in conjunction with the throat fan and is continuous with the intermandibularis posterior.

Mandibulohyoideus I

Origin: on the medial surface of the posterior half of the ramus.

Insertion: to almost the entire length of the first ceratobranchial.

This muscle lies immediately deep to the intermandibularis posterior, lateral to the hyoglossus, medial to the pterygomandibularis and superficial to the branchiohyoideus. The intermandibularis rises to the surface through interdigitations with this muscle.

Mandibulohyoideus II

Origin: by a thin, broad band of fascia from the dentary symphysis and the adjacent bone.

Insertion: on the anterior portion of the first ceratobranchial near the body of the hyoid.

The insertion may extend down the anterior half of the first ceratobranchial on the ventral and ventrolateral surfaces.

Hyoglossus

Origin: from ceratobranchial I.

Insertion: to the lingual process of the hyoid and the fleshy base of the tongue.

This muscle is deep to the posterior portion of the genioglossus and superficial to the brachiohyoideus. It occupies the space between the ceratohyal and ceratobranchial I.

Genioglossus

Origin: from the anterior third of the mandible anterior to the origin of mandibulohyoideus I.

Insertion: on the first ceratobranchial near the body of the hyoid and also by fascia into the covering fascia of the dorsal surface of mandibulohyoideus I.

The origin is deep to that of mandibulohyoideus II and the insertion is superficial to the hyoglossus.

Branchiohyoideus

Origin: from the center of the ceratohyal.

Insertion: to the posterior portion of ceratobranchial I.

This small muscle fills almost the entire space between the hyoid bones except for the most medial portion.

In *Crotaphytus* and *Sauromalus* this is a much smaller muscle which is confined to the lateral portion of the space between the hyoid bones. It is fairly broad in *Ctenosaura* but does not fill the entire space.

Constrictor laryngi

Origin: from the midventral line of the cricothyroid cartilage.

Insertion: to the middorsal line of the epiglotic cartilage.

Dilator laryngi

Origin: from the base of the cricothyroid cartilage.

Insertion: to the dorso-lateral surface of the posterior process of the cricothyroid cartilage.

Episterno-cleido-mastoideus

Origin: from the ventral surface of the clavicle, from the ventral surface of the sternum by

a heavy, broad band of fascia which does not develop muscle fibers until it passes over the clavicle and, usually, a slip of varying size which rises from the fascia of the episternohyoideus superficialis.

Insertion: to back of quadrate and lateral surface of exoccipitals.

The origin is superficial to that of the omohyoid. The muscle lies deep to the constrictor colli and the depressor mandibularis group. In the other species of *Sceloporus*, except in the specimen of *grammicus* which was examined, there was also a slip from the surface of the episternohyoideus superficialis. However, the variability of the development of this muscle in *clarki* would suggest that the condition in the single specimen of *grammicus* might not always be the case.

Crotaphytus may have a slip from the sternohyoideus superficialis, depending on the species. *Ctenosaura* has a doubleheaded episterno-cleidomastoideus. *Sauromalus* has no carry-over of muscle fibers from the sternohyoideus superficialis. Avery and Tanner reported a single head in the specimen of *Sceloporus magister* they dissected.

Omohyoideus

Origin: from the scapula and the lateral part of the clavicle.

Insertion: into the body of the hyoid and the whole of ceratobranchial I.

This is a straplike muscle, triangular in cross-section, which is deep to the intermandibularis posterior and constrictor colli, medial to mandibulohyoideus I and superficial to the insertion of the episternohyoideus superficialis. The origin is covered by that of the episterno-cleidomastoideus. In one case the omohyoid took part of its origin from the midline fascia superficial and lateral to the episternohyoideus superficialis. In another case this muscle was markedly asymmetrical in its development. In some cases a raphe was present in the center of the muscle at the level of the raphe marking the insertion of the episterno-hyoideus profundus into the fibers of the episternohyoideus superficialis, which lies medial of the omohyoid.

This muscle was well developed in most of the other species of *Sceloporus*. In *undulatus* and *chrysostictus* it was thin, straplike and rectangular in cross-section. In *chrysostictus* the muscle was elongated, as were the episternohyoideus and episterno-cleido-mastoideus, due to the lengthening of the neck and hyoid apparatus in this species.

The investigators of *Crotaphytus* and *Sauromalus* did not find the omohyoid to be distinguishable from the episternohyoideus. Sanders illustrates a well-developed omohyoid in *Phrynosoma*. In *Ctenosaura* the muscle was present and rectangular in cross-section.

Episternohyoideus superficialis

Origin: by a thin, broad fascia from the interclavicle and the fascia covering the pectoralis.

Insertion: onto almost the entire length of ceratobranchial I.

The origin of this muscle is superficial to the pectoralis and deep only to the skin. The insertion is immediately deep to the omohyoid. The body of the muscle runs parallel to the ceratobranchial II and is attached to it by a fascia but no muscle fibers. A varying number of lateral fibers are incorporated into the episterno-cleidomastoideus. In most specimens of *clarki* only one slip of this muscle is present.

Episternohyoideus profundus

Origin: from the midline fascia and interclavicle.

Insertion: into the dorsal surface of the episternohyoideus superficialis by a discernible raphe.

This muscle is either only occasionally present or very difficult to divide from the superficialis.

In *magister*, *undulatus*, and *malachiticus*, only the superficialis was present. In one specimen of *variabilis* the muscle was single. In the other, the superficialis inserted onto the proximal portion of ceratobranchial I and completely enveloped ceratobranchial II. In *grammicus* the muscle had a single origin but a double insertion. One insertion was to the body and proximal portion of ceratobranchial I, while the other slip was to the most distal portion of ceratobranchial I. In *poinsetti* the profundus extends to the dorsal surface of ceratobranchial I. The superficialis extends to the ventral surface of the proximal portion of ceratobranchial I with additional fibers to the medial and lateral surfaces. In *chrysostictus* it was single with a heavier concentration of fibers to the proximal section of the first ceratobranchial. In this species the elongation of the neck has caused the ceratobranchial I to lie parallel to the ramus of the mandible for a longer distance than is found in other species of *Sceloporus*. This elongation of the ceratobranchial has caused the episternohyoideus to assume the shape of a parallelogram rather than the fan-shape found in other species.

In *Crotaphytus* and *Sauromalus* this muscle was found to have a midventral fold which causes it to have the appearance of two muscles. Sanders illustrates (1874, fig. 1) a narrow, bandlike episternohyoideus.

JAW MUSCULATURE

Levator anguli oris

Origin: from the squamosal, postorbital and dorsal portion of the tympanic crest.

Insertion: into the skin of the corner of the jaw and the mundplatte.

This muscle lies directly below the heavy infratemporal fascia. It is superficial to the adductor mandibularis externus. The mundplatte into which this muscle inserts, is a heavy sheet of fascia which arises on the postorbital bar and inserts onto the articulare. The mundplatte is the only fascial sheet in *Sceloporus* which is underlain by a fold of skin.

In *Ctenosaura* and *Crotaphytus* the levator also takes origin from the medial surface of the infratemporal fascia.

Adductor mandibularis externus

Origin: from the posterior portion of the postorbital and squamosal.

Insertion: onto the lateral surface of the posterior third of the ramus of the mandible.

This is the large muscle at the angle of the jaw. It is dorsal to the pterygomandibularis, anterior to the depressor mandibularis group and deep to the levator anguli oris. It is covered by the temporal fascia and the levator anguli oris so that it is not visible directly. In *Sceloporus* it is not easily divided into the component elements and only two portions were found. Three were reported from *Ctenosaura*, *Crotaphytus* and *Sauromalus*.

Depressor mandibularis

Origin: from the dorsal aponeurosis.

Insertion: into the back of the mandible.

The group of depressor mandibularis muscles appears on the lateral surface of the head and neck. They lie deep to the constrictor colli, superficial to the episterno-cleido-mastoideus and axial muscles and anterior to the trapezius. In *Sceloporus* three muscle slips are separable. The anterior two are usually divided from the posteriormost and are termed the depressor mandibularis. The posterior section is usually called the cervicomandibularis in anatomical studies but could be called the depressor mandibularis posterior.

Depressor mandibularis anterior

Origin: from the back of the parietal and the very anterior portion of the dorsal aponeurosis.

Insertion: on the articulare.

If heavily developed, this muscle will mask the back half of the temporal opening. It extends posteriorly for a short distance from its origin then turns ventrad and lies along the posterior margin of the external auditory meatus. The muscle fibers are replaced by a tendon approximately at the middle of the auditory meatus which then passes below the tendon of insertion of the depressor mandibularis lateralis.

Depressor mandibularis lateralis

Origin: from the cervical portion of the dorsal aponeurosis.

Insertion: on the articulare.

The lateralis is much broader and thicker than the anterior slip. It extends ventrad from its origin and then turns anterior to its insertion. The insertion and ventral portion of the belly cover the posterior portion of the anterior slip.

Cervicomandibularis

Origin: from the dorsal aponeurosis at the level of the more posterior cervical vertebrae.

Insertion: in the fascia of the intermandibularis posterior and on the back of the ramus.

From the broad origin the fibers of the muscle extend ventrally and anteriorly to converge at the insertion. The breadth of origin and thickness of development are variable, but there did not seem to be any correlation between development and either size or sex. The development of the muscle ranged from a broad, straplike muscle to a thin sheet of fascia with a few muscle fibers scattered through it. In one individual it was not discernible. Its variability, posterior origin, and weak insertion would indicate that it is the weakest of the jaw depressors.

This muscle was similar in the other species of *Sceloporus*, except that in one specimen of *undulatus* the fascia of insertion was into the ventral midline at the level of the hyoid body.

Three section of this muscle were present in *Sauromalus*, *Ctenosaura*, *Phrynosoma*, *Iguana* and *Crotaphytus wislizeni* and *reticulatus*. *Crotaphytus collaris* is reported as having only two bundles which seem to be the anterior and lateral slips. According to Sanders the cervicomandibularis (his neuro-mandibularis) was a well-developed band which inserted onto the back of the mandible. Camp (1923, Fig. 45) indicates in *Phrynosoma* that the insertion was into the fascia of the central part of the intermandibularis posterior.

Shoulder Girdle Musculature

Trapezius

Origin: from the dorsal aponeurosis at the level of the posterior cervical and anterior dorsal vertebrae.

Insertion: onto the scapula by the overlying fascia.

The anterior portion of this muscle lies deep to the cervicomandibularis. The posterior portion is superficial to the latissimus dorsi and the axial musculature. In two specimens some fibers inserted into the lateral section of the clavicle next to the origin of the episterno-cleido-mastoideus.

Crotaphytus was also noted to have a partial insertion onto the clavicle. Sanders (1874) reported that the specimen of *Phrynosoma,* which he examined, had no trapezius. Jenkins and Tanner (1968) found a narrow trapezius in *Phrynosoma platyrhinos* and *douglassi.*

Latissimus dorsi

Origin: from the dorsal aponeurosis of most of the dorsal vertebrae.

Insertion: on the processus latissimus dorsi just below the head of the humerus between the scapular and coracoid heads of the triceps.

This is the largest of the superficial dorsal muscles. The posterior border is sometimes difficult to determine as fibers running at the same angle are present in the fascia to the level of the sacrum. Its borders are further disguised by a heavy concentration of melanophores which occur in the surface fascia of the entire body.

In *poinsetti* the latissimus dorsi was only one fiber thick so that the iliocostalis and the tendons of the spinalis and semispinalis were visible. The insertion fibers appeared to be as heavy, however.

In *Phrynosoma,* Sanders (1874) found the latissimus to be only a narrow band arising from the level of the spines of the third and fourth dorsal vertebrae. Jenkins and Tanner (1968) reported a broad latissimus dorsi originating from the superficial dorsal fascia.

Serratus dorsalis

Origin: by three slips from the cervical ribs.

Insertion: on the medial surface of the scapula dorsal to the insertions of the serratus ventralis and subscapularis.

These muscles, which form part of the sling by which the anterior limb is attached to the body, are visible when the lattissimus dorsi and trapezius are cut and the scapular elements are pulled away from the body.

In *Phrynosoma* Sanders (1874) found only two slips to the dorsal section of the serratus. Jenkins and Tanner (1968) reported three slips of this muscle.

Serratus ventralis

Origin: from the middle of the first thoracic ribs.

Insertion: on the posterior margin of the scapula posterior to the insertions of the serratus dorsalis and subscapularis.

In *Crotaphytus* the serratus ventralis had two slips rather than one large muscle. In this case they also took origin from the cervical ribs.

Subscapularis

Origin: from the medial surface of the suprascapula and scapula ventral to the insertion of the serratus ventralis.

Insertion: onto the proximal, medial surface of the humerus.

In *Crotaphytus,* two slips of this muscle were reported.

Biceps brachii

Origin: originates by two broad, flat tendons from the ventroposterior margin of the coracoid.

Insertion: by a single tendon into the tendon of insertion of the humeroantebrachialis.

This is the largest muscle of the anterior surface of the humerus. The anterior tendon develops a small flat belly of muscle which runs almost to the shoulder joint which it crosses as a broad tendon just posterior to the insertion of the pectoralis. This becomes the lateral belly of the biceps. The tendon of the medial belly remains tendinous from its origin, over the shoulder joint, until the belly develops approximately one-third of the way down the humerus. The two bellies join in the distal third of the brachium and a single tendon moves over the elbow to its insertion.

Robison and Tanner (1962, p. 16) consider this unit to be composed of two muscles, after Mivart's (1867) work on *Iguana.* The anterior belly is considered to be a separate muscle—the brachialis inferior. Romer (1924) considers the muscle to be single but doubleheaded. Sanders considers the muscle in *Phrynosoma* to consist of the biceps and the brachialis anterior. The inclusion of muscle fibers in the anterior head as it passes over the coracoid is not mentioned elsewhere.

Coracobrachialis brevis

Origin: from the majority of the medial portion of the coracoid.

Insertion: to the proximal two-thirds of the medial surface of the humerus.

The origin is deep to the tendons of origin of the biceps brachii. In *Iguana* Howell (1936) found two slips of this muscle. In *Phrynosoma* the insertion is to nearly the entire length of the humerus.

Triceps brachii

This is the large muscle on the posterior surface of the brachium. The origins of the various slips are well separated, but the insertion is by a common tendon which passes over the elbow to insert onto the olecranon of the ulna and which contains the sesamoid ulnar patella.

Lateral humeral head of the triceps

Origin: from the lateral surface of the proximal half of the humerus.

Insertion: into the common tendon.

This head of the triceps lies lateral to the scapular head and joins with it halfway down the brachium.

Medial humeral head of the triceps

Origin: from the medial surface of the humerus about halfway down the shaft.

Insertion: into the common tendon.

This head of the triceps lies medial to the scapular head. It joins the other heads of the triceps just before the tendon crosses the elbow joint.

Scapular head of the triceps

Origin: by a heavy tendon from the posteroventral corner of the external surface of the scapula.

Insertion: into the common tendon.

This head of the triceps joins the lateral humeral head at approximately the middle of the brachium. It is joined to the coracoid head by a sling tendon in all examined species of *Sceloporus*. This tendon was not noted in *Crotaphytus* and *Sauromalus* but was noted to be strongly developed in *Iguana* by Howell (1936).

Coracoid head of the triceps

Origin: by a strong tendon either directly from the posterior portion of the medial surface of the coracoid or from the sternoscapular ligament.

Insertion: into the common tendon.

This is the most variable head of the triceps. In *clarki* the head varied from strongly developed to completely degenerated. In the case where the belly was completely degenerated the tendon was still present. If the belly is present, it develops at the level of the insertion of the latissimus dorsi. The slip lies medial to the scapular head and superficial to the medial humeral head. The sling tendon was well developed in *magister, chrysostictus* and *undulatus*. It was rather weakly developed in *grammicus* and *malachiticus*.

In *Phrynosoma* and Mivart's (1867) *Iguana* account, the inner (coracoid) head of the triceps receives a tendon from the latissimus dorsi, very close to the latter's insertion. From the illustration, this appears to be the sling tendon.

In *Sceloporus* the sling tendon is connected with a subscapular ligament and together they form a complicated set of tendons. The subscapular ligament usually has three points of connection. The most lateral point is that of a strong but narrow tendon which arises from the posterior corner of the coracoid. The tendon of origin of the coracoid head of the triceps arises from this tendon a few millimeters from its origin. The tendon runs medially where an anterior tendon extends forward to the fascia of insertion of the levator scapula profundus. The original tendon then continues medially to the anterior portion of the costocoracoid muscle. The three points of connection then are the posterior corner of the coracoid, the back of the levator scapulae profundus, and the sternum, by the fascia of the costocoracoid.

Variations of this basic pattern were specimens of *clarki* in which the coracoid head arose directly from the coracoid in conjunction with the subscapular ligament, and specimens of *undulatus* in which an additional slip of muscle from the center of the first abdominal rib enters the costocoracoid where that muscle becomes tendinous and enters the subscapular ligament. In *grammicus* the ligament proceeds directly from the sternum to the coracoid without sending an extension to the levator scapulae profundus. This species also has the extra slip of the costocoracoid.

Howell (1936, p. 200), in his dissection of *Iguana*, notes a similar, but not identical, situation:

"Thus, in *Iguana*, the scapulo- and coracotriceps arise from a continuous sling or loop, suspended laterally between scapula and humerus and medially between sternum, coracoid and scapula."

In the dissections of *Crotaphytus* and *Sauromalus*, no mention is made of the sling tendon between the scapular and coracoid heads of the triceps but in their discussion of the costocoracoid, Robison and Tanner (p. 20) note that "the costocoracoid . . . inserts, just dorsal to the mid-

region of the first subscapularis, on a ligament which extends between the inner surface of the sternum . . . and the anterior border of the scapula."

Costocoracoid

Origin: from the medial portion of the first abdominal rib and from the lateral margin of the posterior half of the sternum.

Insertion: to the back of the coracoid by the sternoscapular ligament.

This muscle consists of fibers which arise from the first rib and the sternum posterior to the point from which the ligament extends to the back of the coracoid and a broad, flat sheet of fascia anterior to the point of attachment of the ligament.

In *grammicus* and *undulatus* there is also a slip from the center of the first abdominal rib into the costocoracoid just before it becomes tendinous.

Axial Musculature

Rectus abdominis superficialis

Origin: on the anterior margin of the pubis.

Insertion: on the last abdominal rib posterior to the origin of the pectoralis.

This is the large superficial muscle of the belly. The identity of the lateral boundaries of of the rectus is lost in the middle of the belly as fibers from the rectus are incorporated into the obliquus externus. In *Sceloporus* there are three inscriptions in the body of the muscle.

Rectus abdominis internus

Origin: from the symphyseal area of the pubis.

Insertion: into the midventral line or, in some cases, onto the last abdominal rib.

In *clarki* the rectus internus inserts into the midventral line to the level of the xiphisternal ribs, resulting in a triangular muscle. In other species the muscle inserts into only the posterior section of the midventral line. In *grammicus* and one specimen of *chrysostictus* the insertion was directly onto the xiphisternal ribs.

Obliquus externus

Origin: from the middle of the body of the dorsal ribs.

Insertion: into the midventral line of the dorsal surface of the rectus abdominis.

The direction of the fibers is ventral and posterior. Since fibers of the muscle do not arise from the posterior dorsal vertebrae, there remains a triangular space in front of the hind leg in which the viscera is covered only by the peritoneum, the thin sheets of the obliquus internus, and the transversus abdominis.

In some individuals the slips retain individual identity as they arise from the ribs almost to their insertion posterior to the point where the posterior margin of the latissimus dorsi crosses the level of the insertion of the obliquus internus. This tendency was also noted in *magister*.

Musculature of Hind Limb

Ambiens

Origin: from the anterior surface of the femur near the head below the insertion of pubo-ischio-femoralis internus.

Insertion: onto the patellar capsule and the head of the tibia.

This muscle covers the leading edge of the thigh. In *Sceloporus* the muscle is single and simple. The origin is covered by the origin of the femorotibialis.

Femorotibialis

Origin: broadly from the head of the femur and the fascia of the pubo-ischio-femoralis internus.

Insertion: broadly to the head of the tibia, just proximal to the insertion of the flexor tibialis internus superficialis.

This muscle is visible on the ventral surface of the thigh posterior to the ambiens and anterior to the pubo-ischio-tibialis. It extends diagonally from its origin beneath the pubo-ischio-tibialis and the insertion of the adductor.

Pubo-ischio-tibialis

Origin: from the puboischiadic ligament

Insertion: onto the tiba by a broad tendon which it has in common with the flexor tibalis externus.

This is the largest muscle of the ventral surface of the thigh. The insertion is on the anterior surface of the tibia between the bodies of the tibialis anterior and the extensor digitorum communis several millimeters below the patella. This muscle lies directly below the femoral pores and bears their imprint in preserved specimens.

In *poinsetti* the muscle is less heavily developed and has a definite slip between the main portion and the flexor tibialis externus. It inserts into the broad tendon of the main part of the muscle by a thin band which remains visible in the fascia across to the tibia. In *malachiticus*

the common tendon enters the tibia just below the knee joint.

Flexor tibialis externus

Origin: from the tubercle of the ischium and the ilioischiadic ligament.

Insertion: into the body of the pubo-ischio-tibialis before it becomes tendinous.

This muscle occupies the posterior border of the thigh. In all species examined the flexor enters into the pubo-ischio-tibialis before that muscle crosses the knee, although there is some variation in the distance above the knee the junction occurs. In some specimens of *clarki* some of the more posterior fibers of the flexor enter the tendon rather than the muscle. In *undulatus* the more posterior fibers give rise to a small, independent tendon which crosses the knee posterior to the larger tendon.

In *Phrynosoma* and *Iguana* the flexor tibialis externus crosses the knee independently.

Flexor tibialis internus

Origin: from the ilio-ischiadic ligament deep to the origin of the flexor tibialis externus.

Insertion: by three tendons on the head of the tibia.

The flexor tibialis internus splits into three bellies at the level of the head of the femur. The largest belly inserts broadly to the head of the tibia immediately deep to the common tendon of the pubo-ischio-tibialis and the femoro-tibialis. Of the two smaller bellies, one belly develops a long, narrow tendon two-thirds of the way down the thigh which inserts into the posterior surface of the head of the tibia. This is the deepest slip. The third slip is slightly posterior to the other two and develops a tendon of insertion just proximal to the knee joint.

Popliteus

Origin: from the postero-lateral surface of the head of the fibula.

Insertion: into the tendon of the flexor hallucis longus.

In *Sceloporus* the popliteus is an extremely short muscle which arises directly from the bone. The fibers wrap around the tendon of the flexor hallucis longus. This is almost the mammalian condition rather than the normal reptilian condition of a well-developed popliteus.

Gastrocnemius

Origin: the lateral head from the head of the fibula, the medial from the head of the tibia.

Insertion: by a common tendon into the plantar aponeurosis.

In *Sceloporus* this muscle is two-headed and two-bellied but has a single insertion and will be considered as a single muscle. In some cases the muscle has been considered as two muscles—the soleus and the gastrocnemius. There has been little agreement over which is which, but most recently George (1948) called the fibular head; the soleus.

Flexor digitorium brevus

Origin: from the tarsals and the plantar aponeurosis.

Insertion: to the ventral surfaces of the phalanges.

This muscle is superficial to the flexor digitorum longus. The palmar aponeurosis is present but is not as heavily developed as has been reported from other lizards. Also, there is no sesamoid bone found, although Cope (1892, p. 196) states that "In all the normal Lacertilia the tendons of the flexors of the digits are combined on the palm and the point of junction is occupied by a large, flat sesamoid bone."

DISCUSSION

Within the genus *Sceloporus*, or at least in the species examined, it can be seen that the myology is generally very constant. Those muscles which are constant within the genus are essentially those which are constant within the members of the family which have been examined.

Etheridge (1964) has indicated that *Sceloporus* is an advanced iguanid in comparison to other iguanid genera by virtue of osteological characters. Only a limited amount of myological comparison can be made because of the small number of myological studies available within the family.

The muscles in which the greatest variability occurred were the intermandibularis group, the constrictor colli, the episterno-cleido-mastoideus, the episternohyoideus, the coracoid head of the triceps, the costocoracoid, and the flexor tibialis externus. It will be noted that most of this variation is in the neck region.

The variation in the intermandibularis was used by Camp (1923) in the construction of his lizard classification. The results of the present

study are not always in agreement with his conclusions. According to Camp, *Sceloporus* is one of the genera in which separation of the profundus and superficialis bundles of the intermandibularis anterior has occurred, and he states (p. 370) that "in the iguanids, *Callisaurus, Uma* and *Holbrookia*, alone, is the superficial layer absent." It was not noted in any of the species of *Sceloporus* dissected. According to Camp, the number of interdigitations of the intermandibularis posterior with the mandibulohyoideus I can be used for purposes of classification because they are regular and equal. In *clarki* alone, the number of interdigitations ranged from three to seven and usually were not the same in numbr for the two sides. Therfore, the use of this muscle for classification purposes in *Sceloporus* does not seem warranted. Camp's criterion of the primitive iguanid throat musculature is the condition in which there is a higher number of interdigitations of the posterior slip and the lack of or slight separation of the two slips of the anterior slip of the intermandibularis. In this respect, *Sceloporus* would maintain its place as one of the primitive iguanids.

The variable development of the constrictor colli is understandable if its broad development is associated with the throat fan of *Iguana*, while the absence of this throat flap in *Sauromalus* and the other ground iguanids is accompanied by a narrow constrictor colli. The variability of the muscle is less easily understood in the genus *Sceloporus*. It is broadly developed in the tree-living *clarki* and the rock-living *magister*. It occurs as a narrow band in *malachiticus* and *variabilis* which are quite far removed from each other according to Smith (1939). It apparently has no ecological and phylogenetic basis although more data are necessary to draw any conclusions. The behavior of the various species of *Sceloporus* is not well enough known to attempt any correlations.

The comparative development of the intermandibularis posterior and the constrictor colli seems to follow no patterns. In *Sceloporus*, the development of both muscles is variable with no relation between the two. In *Iguana* they are both heavily constructed. In *Sauromalus* both are narrow bands. In *Crotaphytus* and *Ctenosaura* the intermandibularis is broad and the constrictor colli is a narrow band.

The variation of the episterno-cleido-mastoideus seems to be without correlation. All species of *Sceloporus* examined, except *grammicus*, had a double-headed muscle. The variation in the size of the head from the episternohyoideus superficialis was negligible.

The muscles connecting the pectoral girdle and the hyoid apparatus show a great deal of variation. There is controversy among anatomists as to the nature and identification of these muscles. Camp illustrates (fig. 42-47, 53-65) the muscles he calls omohyoideus, sternohyoideus and sternothyreoideus and shows the great diversity of this group of muscles. The three are not always present simultaneously. Of the iguanids studied Camp indicates that all three were present in *Prynosoma*. Avery and Tanner (1964) in *Sauromalus* and Robison and Tanner (1962) in *Crotaphytus* reported that there was a single sheet of muscle folded back on itself at the midventral line. Camp illustrates this condition only in *Gerrhosaurus* (Fig. 63, 66). This folded condition has been reported for no other iguanids. If the muscle deep to the sternohyoideus superficialis is the episternothyreoideus, then the litter muscle is present in *poinsetti* and sporadic in *clarki*.

There is a graduation of conditions in *Sceloporus* of the episternohyoideus supericialis. In *magister, undulatus, malachiticus*, and most specimens of *clarki*, the muscle was single and inserted uniformly on the entire length of the first ceratobranchial. In *chrysostictus* there was a tendency for increase of fiber number to the proximal portion of ceratobranchial I. In one specimen of *variabilis* the muscle fibers were confined to the proximal portion of ceratobranchial I and had shifted part of their insertion to ceratobranchial II. Thus, concentration of fibers to the medial portion of the hyoid occurs in one of Smith's basic divisions of *Sceloporus* while the species with insertion into the whole of ceratobranchial I occur in the other branch. The tendency to develop the deeper slip is noted only for *clarki* and *poinsetti* which are fairly closely related, according to Smith, and would be an independent evolutionary trend.

Perhaps the most interesting of the muscle variations found in this investigation is the variability and the relationships of the subscapular ligament and the related muscles—the coracoid head of the triceps, the costocoracoid and the levator scapulae profundus. In the simplest condition the ligament seems to be the tendon of insertion of the costocoracoid in conjunction with a heavy fascia from the anterior edge of the sternum (Robison and Tanner, 1962). In *Iguana* (Howell, 1936), the tendon of the coracoid head of the triceps has entered into the ligament. Howell states that the ligament is presently in *Cyclura* but is less strongly defined, and does not elaborate. *Sceloporus* has added the further refinement of the inclusion of the levator scapu-

lae profundus. At this stage of investigation the only attempt at correlation can be to say that the ligament seems to be more strongly and complexly developed in aboreal iguanids than in the ground dwellers.

The heavy development of the flexor tibialis externus in *Sceloporus* and its insertion on the body of the pubo-ischio-tibialis differ from other iguanids and other lizards. The heavy tibial flexors, which also act as femoral extensors, are used by Snyder (1954) in his analysis of the locomotor components in lizards. He indicates that *Sceloporus* is a natural quadruped, with no possibility of achieving the bipedality of other iguanids. The flexor tibialis externus was the most highly developed in *clarki;* less developed in *magister* and *poinsetti;* moderately developed in *undulatus* and *malachiticus;* and rather weakly developed in *variabilis.* Thus, the decidedly arboreal *clarki* has the most heavily developed flexor while it is rather weakly developed in the ground-dwelling *variabilis.* This muscle would be useful in a half-contracted position in the maintenance of posture on a tree trunk in a highly arboreal animal.

Avery and Tanner (1964, p. 28) have constructed a natural group of the genera *Sauromalus, Ctenosaura,* and *Dipsosaurus* which share the characteristics of (1) an intermandibularis anterior and posterior, (2) a single-headed episterno-cleido-mastoideus, (3) a depressor mandibularis group with three muscles and, (4) an herbivorous diet. They state that, in their opinion, *Sceloporus* differs only in that its species are omnivorous or carnivorous. Further work by Avery has indicated that *Sceloporus* is not very close to the iguanines (pers. comm.).

From the investigation herein described it would seem that the relationship of *Sceloporus* to these genera is not as close as is indicated.

1. *Sceloporus* lacks an intermandibularis anterior superficialis which is present in these genera and the posterior and anterior slips of the muscle are in contact rather than divided.

2. The episterno-cleido-mastoideus usually possesses a slip from the surface of the episternohyoideus superficialis and cannot be considered single-headed.

3. The third head of the depressor mandibularis group, or cervicomandibularis, is usually weakly developed and is sometimes absent.

The folded nature of the episternohyoideus in *Sauromalus* would seem to be a basic difference, as is the simple nature of the subscapular ligament.

These muscle differences would indicate that *Sceloporus* is not too closely related to *Sauromalus* and *Ctenosaura.* This is in agreement with Etheridge's findings (1964).

Crotaphytus is considered by Etheridge to be fairly closely related to the sceloporine lizards. The myology is more similar to that of *Sceloporus* than is that of *Sauromalus,* but there are still

TABLE 1

List of abbreviations used in the figures.

a - ambiens
add - adductor
ame - adductor mandibularis externus
anu - ring muscle

bh - branchiohyoideus

c - cloaca
cb I - ceratobranchial I
cb II - ceratobranchial II
cc - constrictor colli
ch - ceratohyal
cm - cervicomandibularis
co - costocoracoid

dcm - caudae dorsalis

ecd - extensor communis digitorum
ecm - episterno-cleido-mastoideus
chs - episternohyoideus superficialis
eo - obliquus externus

fdc - flexor digitorum communis
ft - femorotibialis
fte - flexor tibialis externus
fti - flexor tibialis internus

g - gastrocnemius
gg - genioglossus

hb - hyoid body
hg - hyoglossus

iap - intermandibularis anterior profundus
ifb - ischiofibularis
ip - intermandibularis posterior
it - ischiotibialis

lp - lingual process

mand - mandible
mh I - mandibulohyoideus I
mh II - mandibulohyoideus II
mh III - mandibulohyoideus III

oh - omohyoideus

pb - peroneus brevis
pect - pectoralis
pifc - pubo-ischio-femoralis
pl - peroneus longus
pt - pubo-ischio-tibialis
ptery - pterygomandibularis

ra - rectus abdominis

sb - subscapular ligament
st - sternum

ta - tibialis anterior
tlsp - tendon to levator scapulae profundus
toc - tendon to origin of coracoid head of triceps
tp - transversus perinei

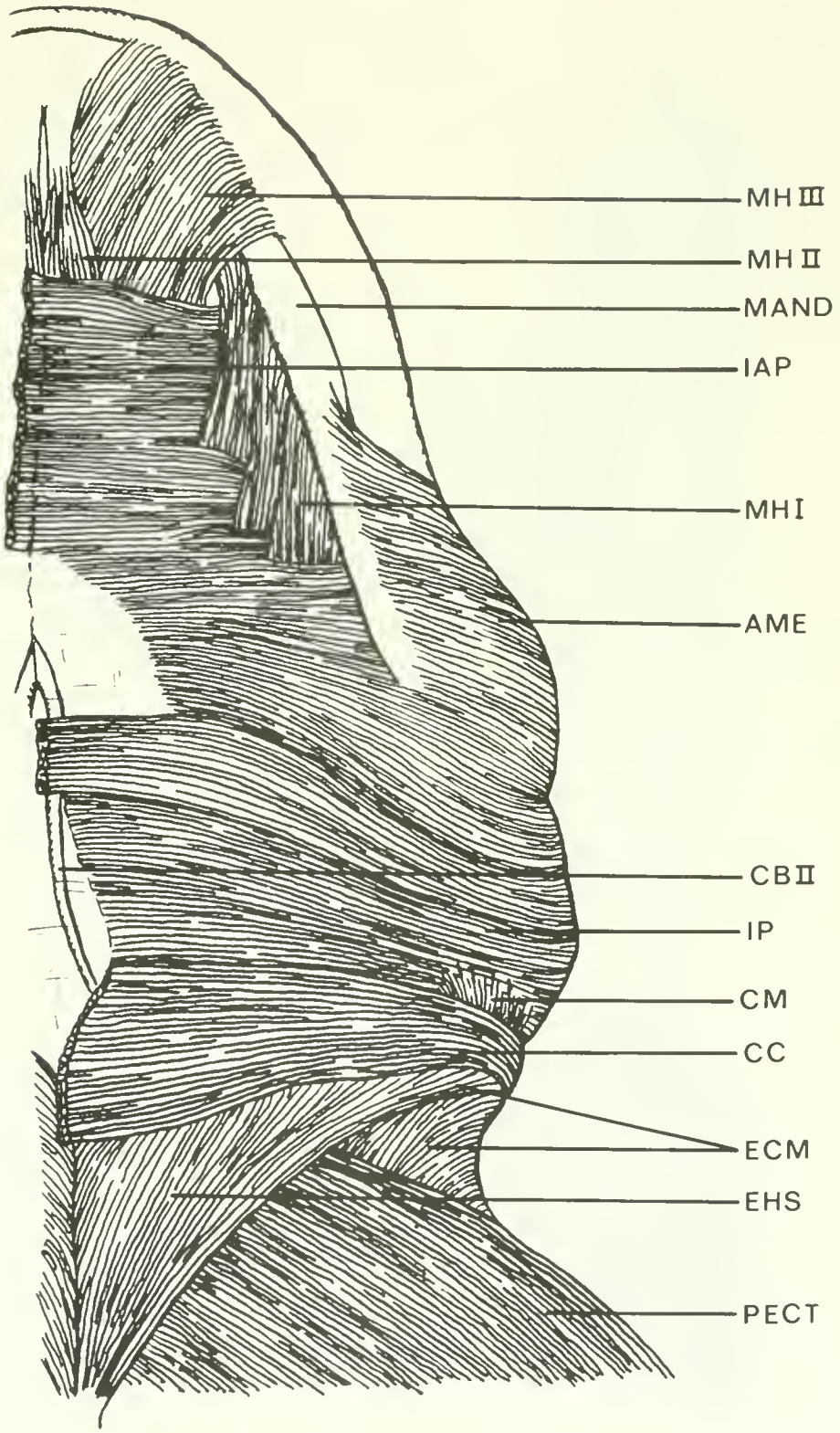

Fig. 1. Ventral view of throat, superficial musculature.

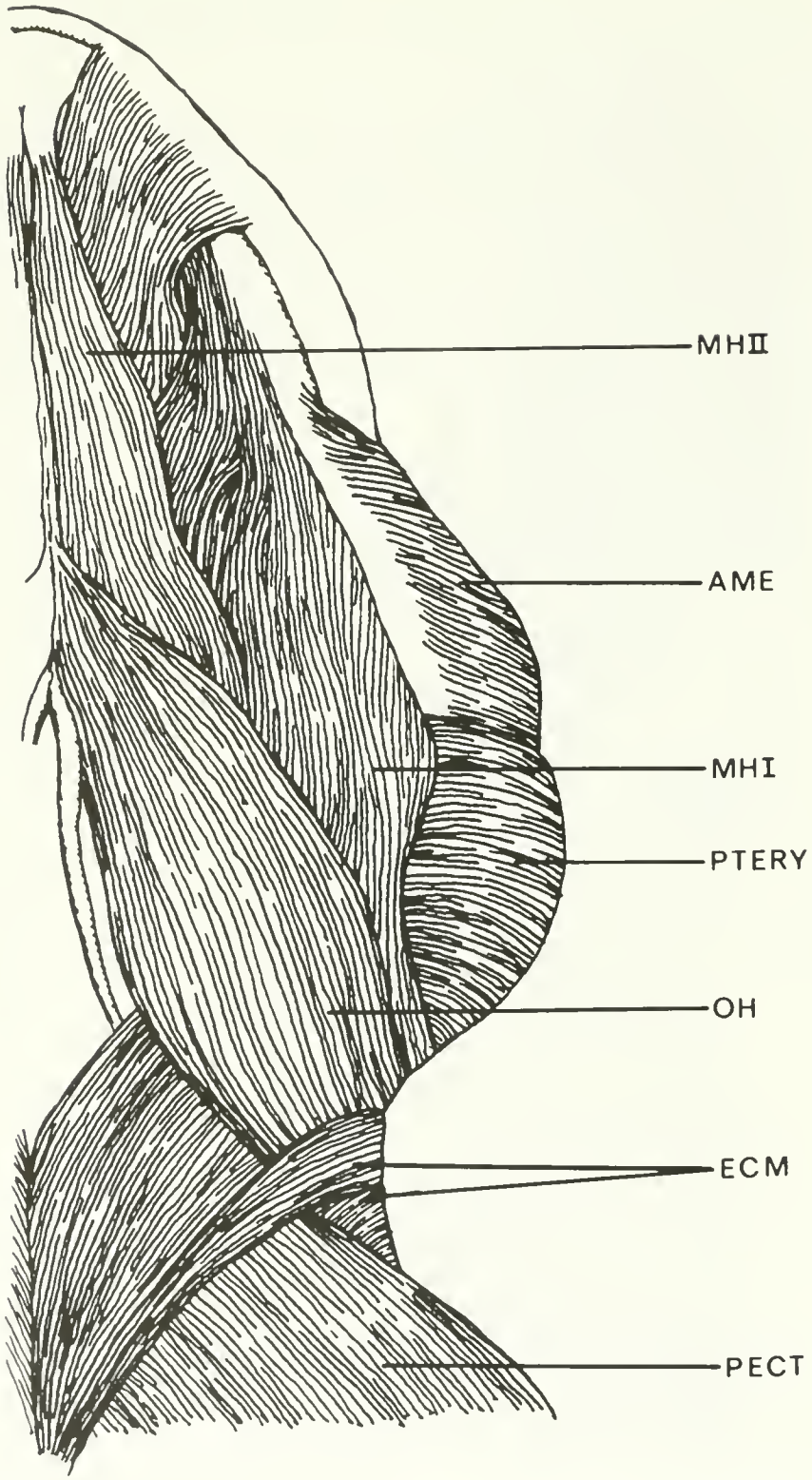

FIG. 2. Ventral view of throat, second layer.

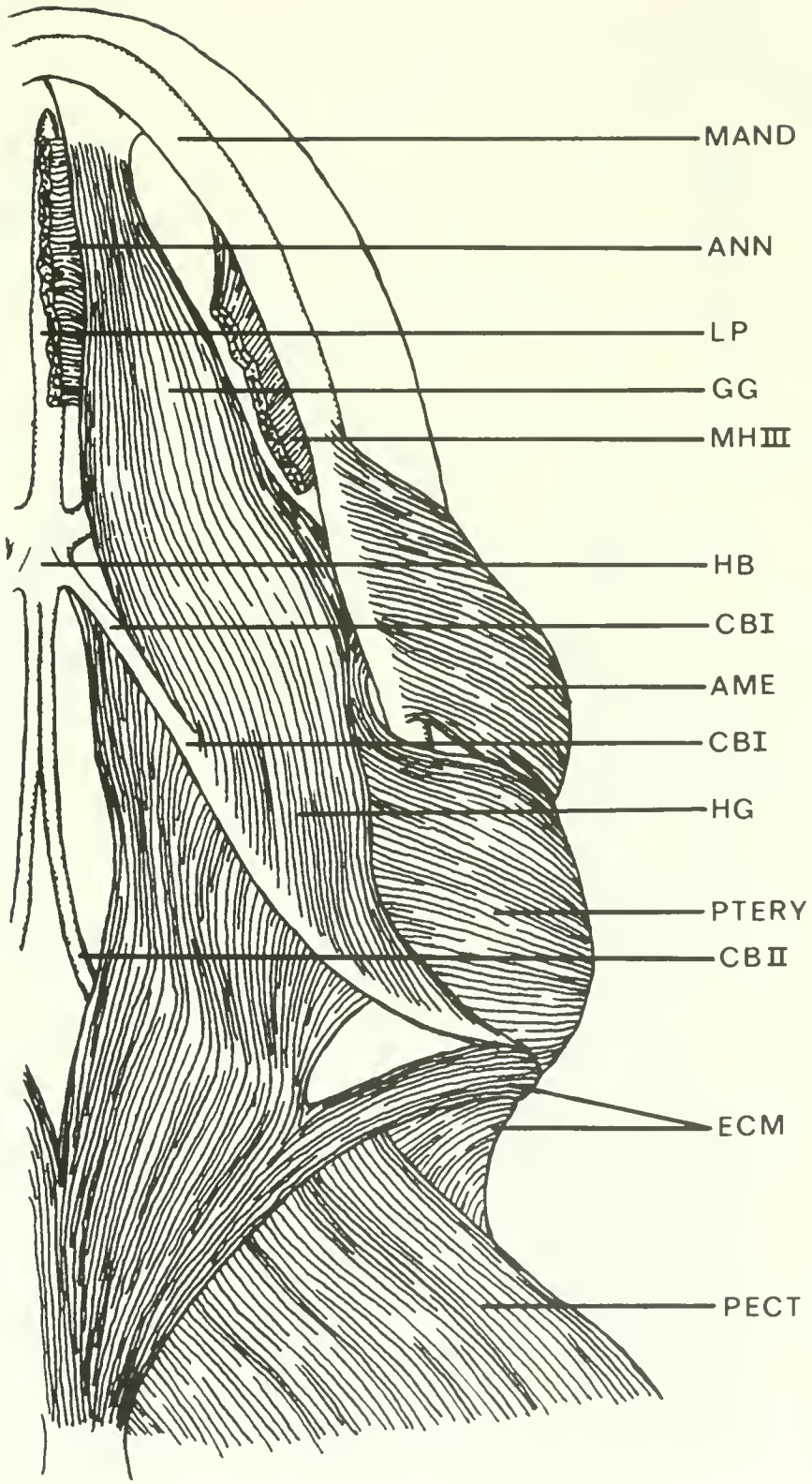

Fig. 3. Ventral view of throat, third layer.

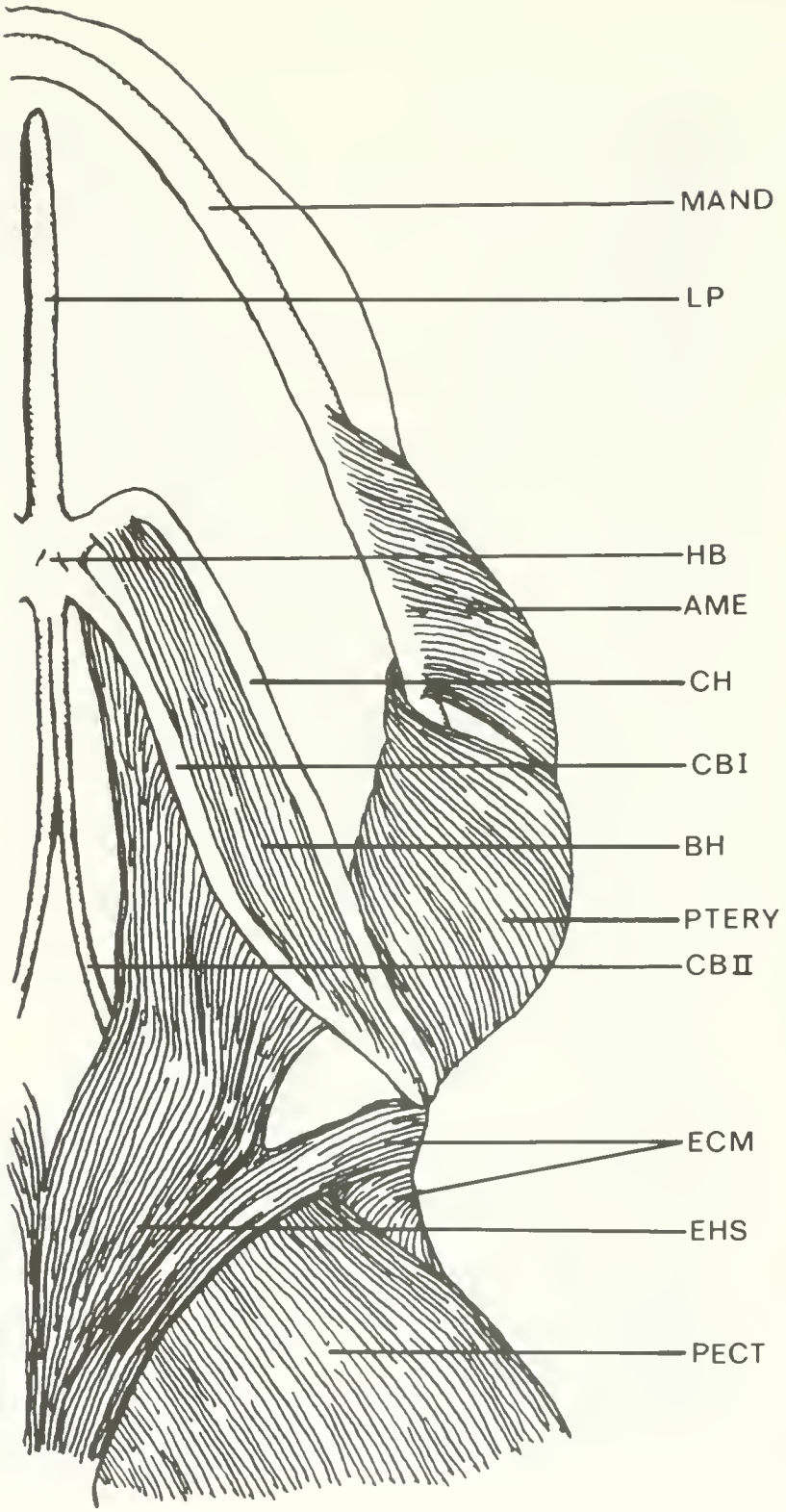

FIG. 4. Ventral view of throat, deepest musculature.

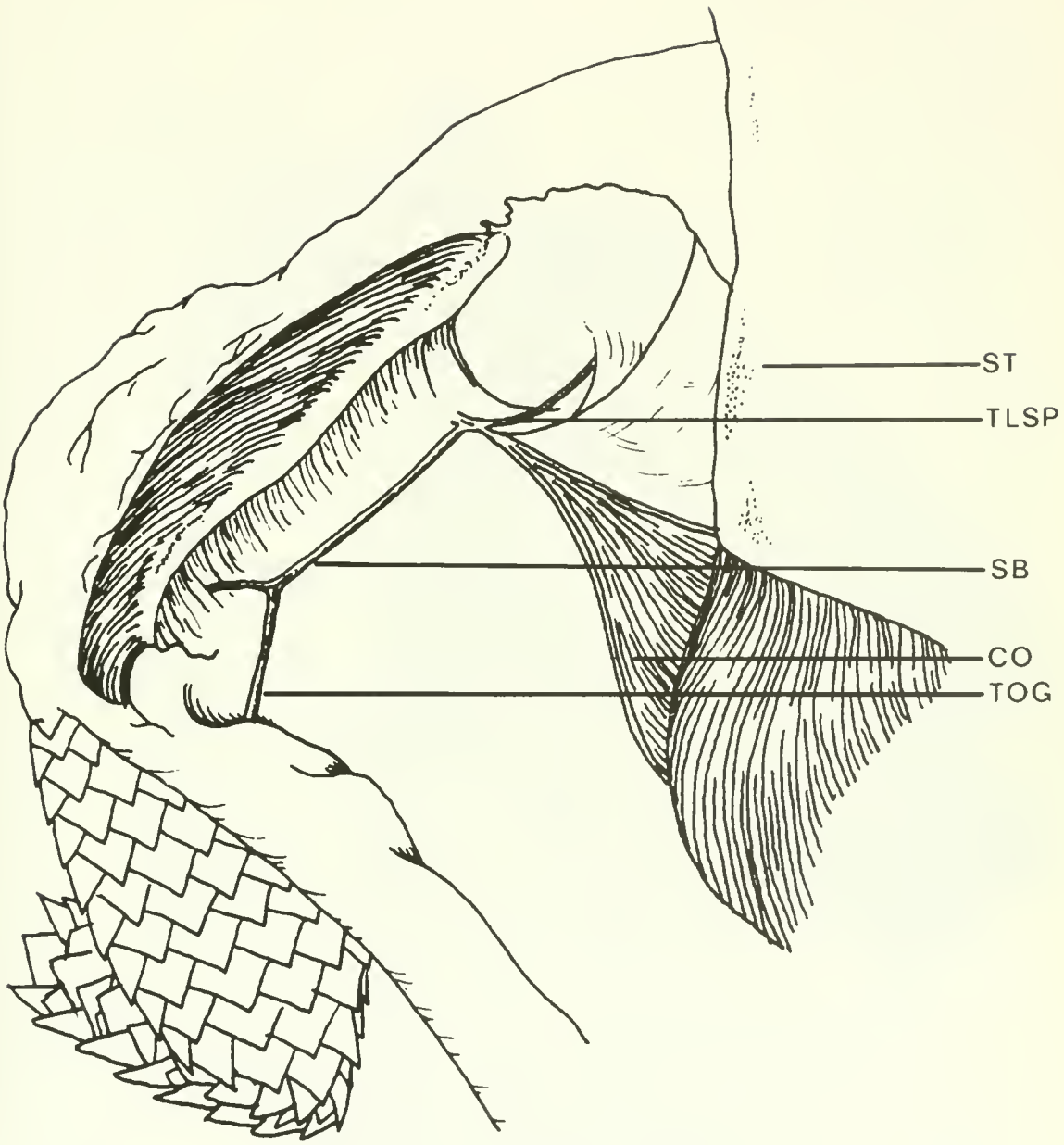

Fig. 5. Subscapular ligament and associated muscles.

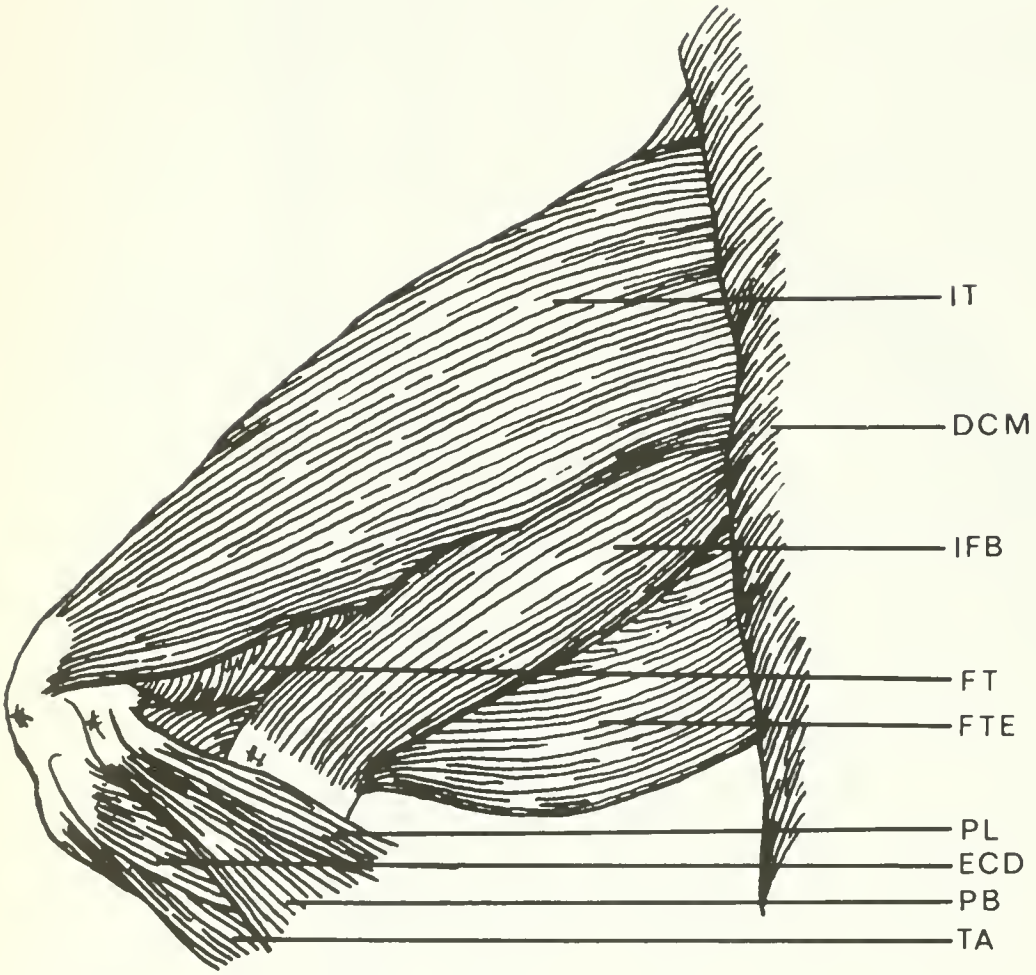

FIG. 6. Dorsal view of superficial musculature of leg.

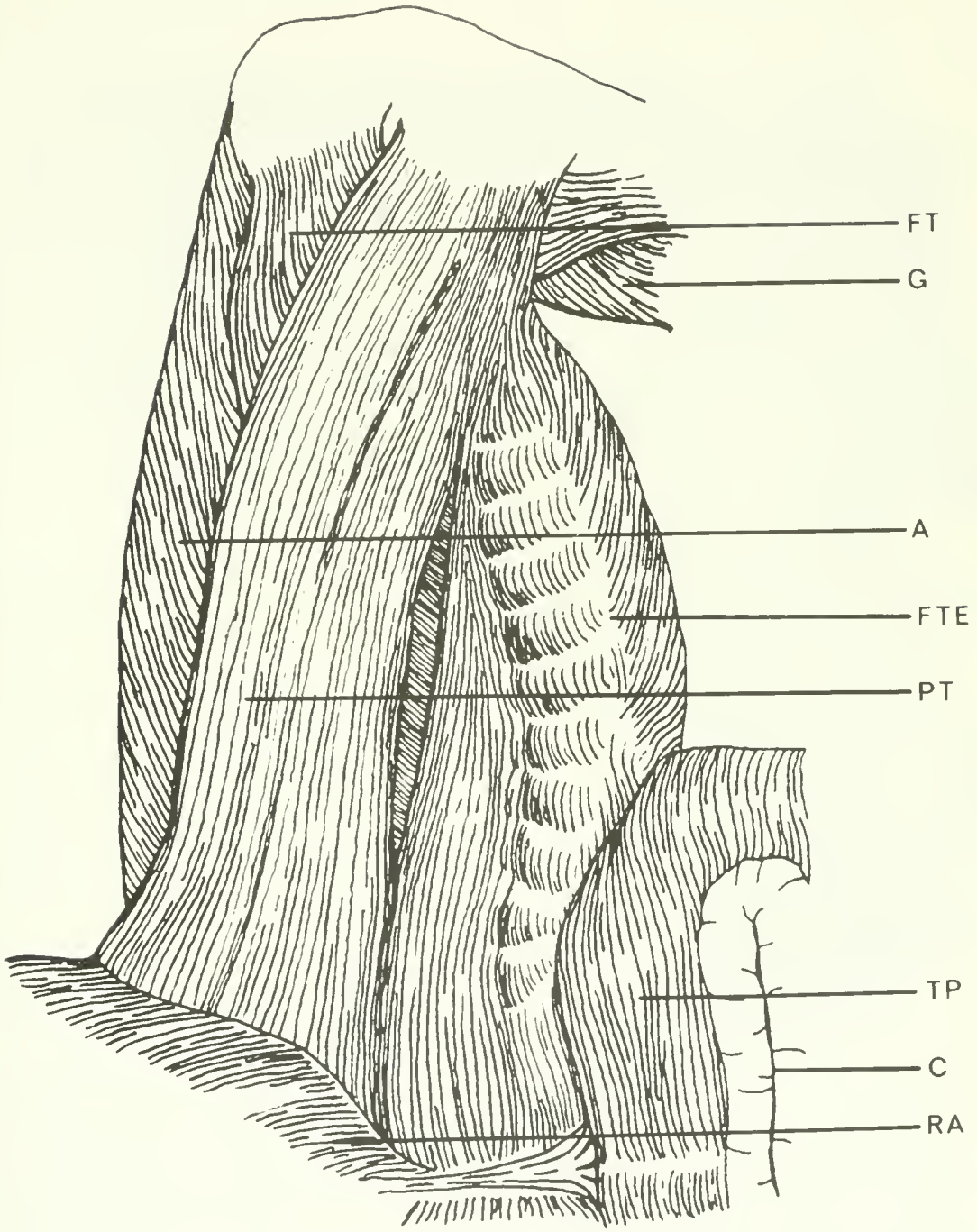

Fig. 7. Ventral view of superficial musculature of leg.

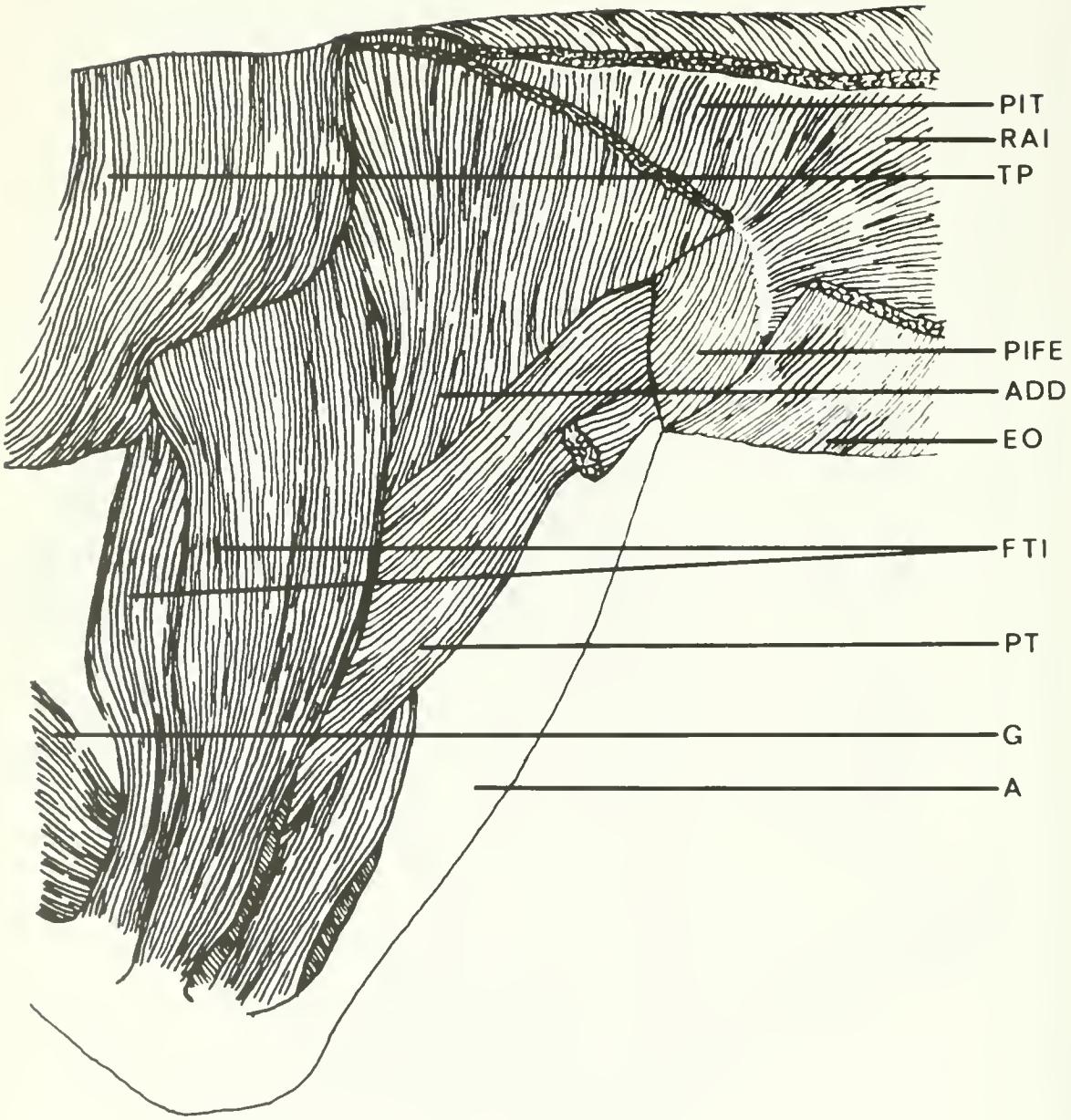

FIG. 8. Ventral view of leg, pubo-ischio-femoralis and flexor tibialis externus removed.

some differences. The intermandibularis anterior and posterior are not separated by fascia as in *Sauromalus*, but they differ from *Sceloporus* in having a definite superficial slip of the anterior. Only two slips of the depressor mandibularis are present in some species of *Crotaphytus*, but three are present in the other species, as in *Sceloporus*. More important are the folded nature of the episternohyoid muscle and the simple nature of the subscapular ligament. The nature of the flexor tibialis externus is not known.

Etheridge (1964) considers *Phrynosoma* to be very closely related to the sceloporine lizards. It differs, according to Camp (1923), by having a very well-developed intermandibularis anterior superficialis. According to the Sanders (1874) the body musculature differs by the absence of the trapezius, an extremely narrow latissimus dorsi and a flexor tibialis externus which crosses the knee independent of the pubo-ischio-tibialis. Jenkins and Tanner (1968) consider that the myological peculiarities of *Phrynosoma* consist of "The divided nature of the M. sternohyoideus, M. subscapularis II, and M. episternocleidomastoideus, and the reduced condition of the M. serratus, M. trapezius, and M. obliquus abdominis externus, and the expanded nature of the M. branchiohyoideus . . . " . Therefore, the body musculature is decidedly different.

It has been shown that there are discernible differences between the species of *Sceloporus*. Little pattern can be seen in the differences and one cannot be projected until further work is done.

Even between the closely related *clarki* and *magister* differences can be seen. *Magister* possesses a constrictor colli which is merged with the intermandibularis posterior; the episternohyoideus profundus is not present; and the iliocostalis is much larger than that found in *clarki*.

CONCLUSIONS

1. *Sceloporus* is not closely related to the ground-dwelling *Sauromalus*, *Ctenosaura* and *Dipsosaurus*.

2. *Crotaphytus* is more closely allied to *Sceloporus* than to the ground-dwelling iguanines.

3. The musculature of *Phrynosoma* is aberrant in several respects, while other aspects indicate that its relationship is not as close to *Sceloporus* as is that of *Crotaphytus*.

4. The high degree of development of the subscapular ligament in all species of *Sceloporus* and its associated development in *Iguana*, an arboreal lizard, would indicate the possibility of the basic stock of *Sceloporus* being arboreal. This is born by the nature of the flexor tibialis externus.

5. The small differences in myology between the species of *Sceloporus* would indicate the presence of a rapidly evolving group with, as yet, little morphological variation.

6. Differences in the myology of reptiles can and do occur at the species group and genus group levels.

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BOTANICAL AND PHYSIOGRAPHIC RECONNAISSANCE OF NORTHERN YUKON

by

Stanley L. Welsh

and

J. Keith Rigby

BIOLOGICAL SERIES — VOLUME XIV, NUMBER 2

JULY 1971

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FRONTISPIECE. Southeast across the northeastern part of the Barn Mountains into Blow River Pass. Linear trails of caribou show in the trampled tundra in the foreground. Creeks in the foreground and intermediate distance are tributaries at the head of Fitton Creek at approximately 68°29′ N; 138°15′ W. The Richardson Mountains show as faint ghosts beyond the sea fog blanketing Blow River Valley.

TABLE OF CONTENTS

INTRODUCTION 1
Accessibility 2
TOPOGRAPHY 4
Old Crow Flats 4
Barn Mountains 8
British Mountains 9
Arctic Coastal Plain 9
Buckland and Babbage Hills 12
Driftwood Mountains 12
WEATHER 13
STRATIGRAPHY 13
VEGETATION 15
Streamsides and Bars 16
Lake Margins 19
Tussock Tundra 20
Alpine Tundra 21
Boreal Forest 24
Maritime Vegetation 26
Aquatic Vegetation 26
COLLECTION LOCALITIES 28
CHECKLIST OF VASCULAR PLANTS 38
ACKNOWLEDGMENTS 63
REFERENCES 63

BOTANICAL AND PHYSIOGRAPHIC RECONNAISSANCE OF NORTHERN YUKON

by

Stanley L. Welsh[1] and J. Keith Rigby[2]

ABSTRACT

The area of study is located in the northern panhandle of the Yukon Territory, and includes the British and Barn Mountains, Old Crow Flats, and the coastal plain of the north slope. The physiography and geology of the region is described and the plant communities are enumerated. An annotated list of 279 species, 15 subspecies, 63 varieties, and 1 form of vascular plants collected during the summer of 1970 is included.

INTRODUCTION

The area of study is located within the northern panhandle of the Yukon Territory (Fig. 1), and extends southward 70 to 80 miles from the shore of the Beaufort Sea across the British and Barn mountains and Old Crow Flats to the Porcupine River, west and southwest of the northern Richardson Mountains. The area under investigation includes the Barn Mountains and Blow River valley on the east, and the British Mountains and Old Crow Flats to the Alaska border on the west (Bostock, 1948). In general the area lies between latitudes 68° and 69° 39′ north and longitudes 138° and 141° west, in the Blow River, Herschel Island, Demarcation Point, Davidson Mountain, Old Crow, and Bell River quadrangles. The collected area occurs in quadrangles 117 A-2-7, 10-15; 117 B-8-9, and 16; 117-C 1, 8-9; and 117-D-3-5, of the National Topographic Survey of Canada.

The central part of the area is approximately 130 miles west of Inuvik, Northwest Territories, and approximately 70 miles north of Old Crow, an Indian village on the Porcupine River.

The British Mountains continue to the west in Alaska as the Romanzof Mountains. The more eastern Barn Mountains are west across the Blow River valley from the northern end of the Richardson Mountains, which are adjacent on the west to the lower Mackenzie River delta.

We arrived at the landing strip on the gravel bar in the Porcupine River upstream from Old Crow (Fig. 2) on June 17 and set up a temporary camp while awaiting the arrival of air transportation to Sam Lake. Camp was established June 18 at Sam Lake, in the topographic saddle between the British Mountains and Barn Mountains at the northeastern edge of Old Crow Flats (Fig. 3). Bonney (Bonnet) Lake to the southeast approximately 20 miles, Trout Lake to the north approximately 45 miles (Fig. 4), and other lakes in the Old Crow Flats area were still frozen. Trout Lake opened up approximately July 1, and Bonney Lake at about the same time, McNeish Lake, east of the mouth of Firth River, remained with ice over much of the lake until mid-July. The small lake in the headwaters of the Firth River, near the braided ice field of the Firth River east of the Alaska border, was clear early in the season on June 20 when we first flew into the area. Sam Lake, and Firth Lake, as we will call it here, are both shallow lakes and apparently warmed more quickly than the deeper clearwater lakes both north and south of the British Mountains.

Timber for tent poles, stakes for tents, poles for a dock, etc., were obtained from a small grove of white spruce trees on the south flank of hills approximately 4 miles northwest of Sam Lake, or from the valley of Dog Creek and Black Fox Creek, 5 to 10 miles to the southwest, the northernmost woods in the area. There is no available timber to the southeast of Sam Lake for some distance. Trees sufficient for low tents and dock construction are available in the Firth

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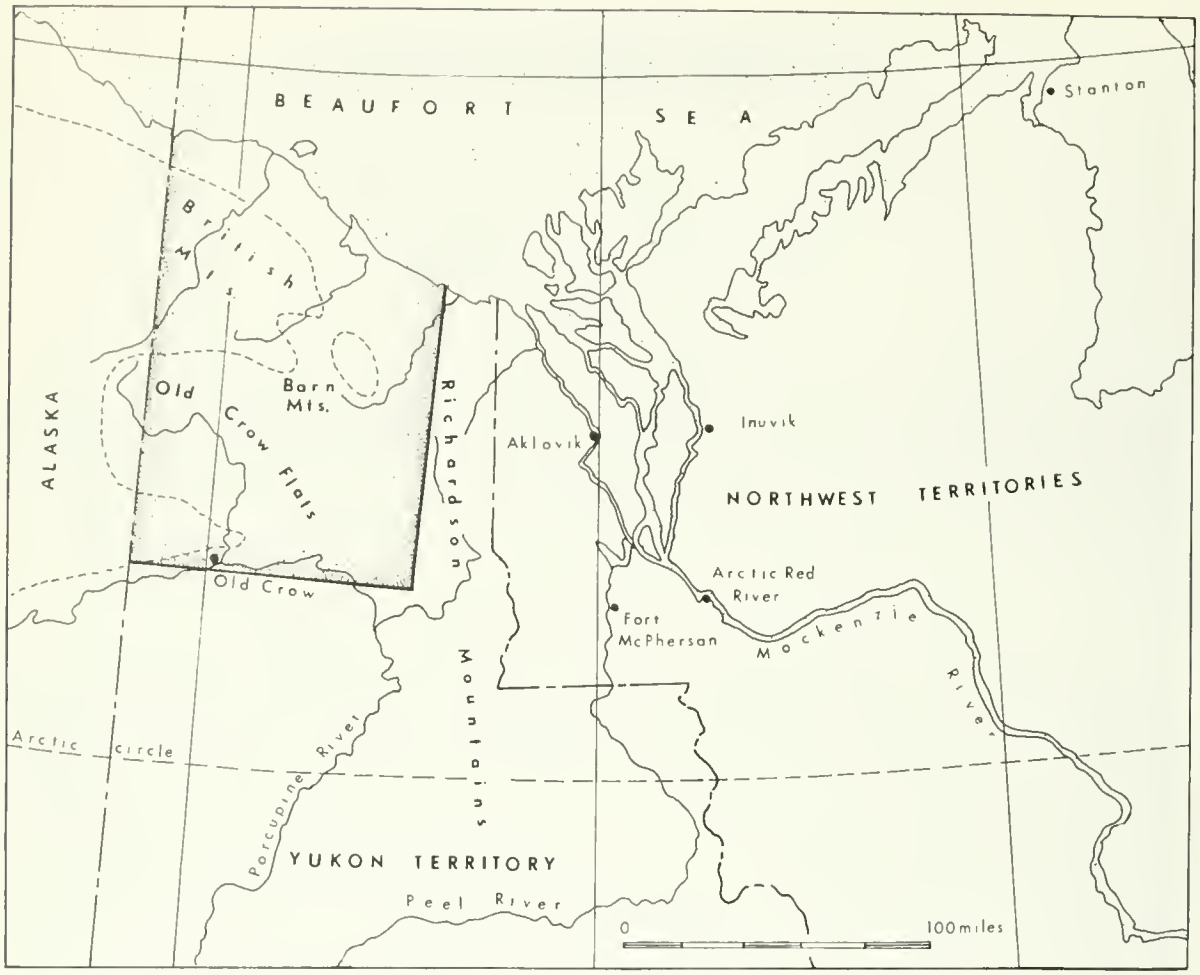

FIG. 1. Regional map of collected area in northern Yukon.

River valley, in the vicinity of Firth Lake and upstream for a short distance. Only willows are growing in the lower part of the Firth and Malcolm river valleys where these rivers empty onto the north slope of the British Mountains and the Arctic coastal plain.

We moved our camp onto a prominent point on the northwestern side of Sam Lake on June 18-19 and experienced some difficulty with tent pegs. First, wooden pegs would not function in the permafrost which was at that time at the surface, necessitating use of long metal spikes (10-12 inches) for initial setting up of equipment. However, as frost level lowered, the spikes did not hold in the spongy ground, and longer stakes were necessary to hold tents in an upright position.

ACCESSIBILITY

Access is currently only by aircraft with floats landing on the few lakes in the mountains and along the mountain flanks. McNeish Lake, Trout Lake, and other lakes along the north flank, and Bonney Lake, Sam Lake, Firth Lake, and other minor lakes along the south flank of the British Mountains are usable by planes of Otter size and smaller. Several lakes in Old Crow Flats are also deep enough and large enough for emergency use, but most are so far from solid camp areas that they are impractical for anything but transshipment points.

A very short semigraded strip is located at the head of Fitton Creek near a mine prospect on the east side of the Barn Mountains, northeast of Mt. Fitton, but is soft during the summer. A landing strip capable of handling a DC-3 is nearing completion at the village of Old Crow on the Porcupine River and will give year-round use. The first planes landed there during late July of 1970 on the unfinished runway. This is an improvement over the gravel channel bar in the middle of the Porcupine River, 10 miles up-

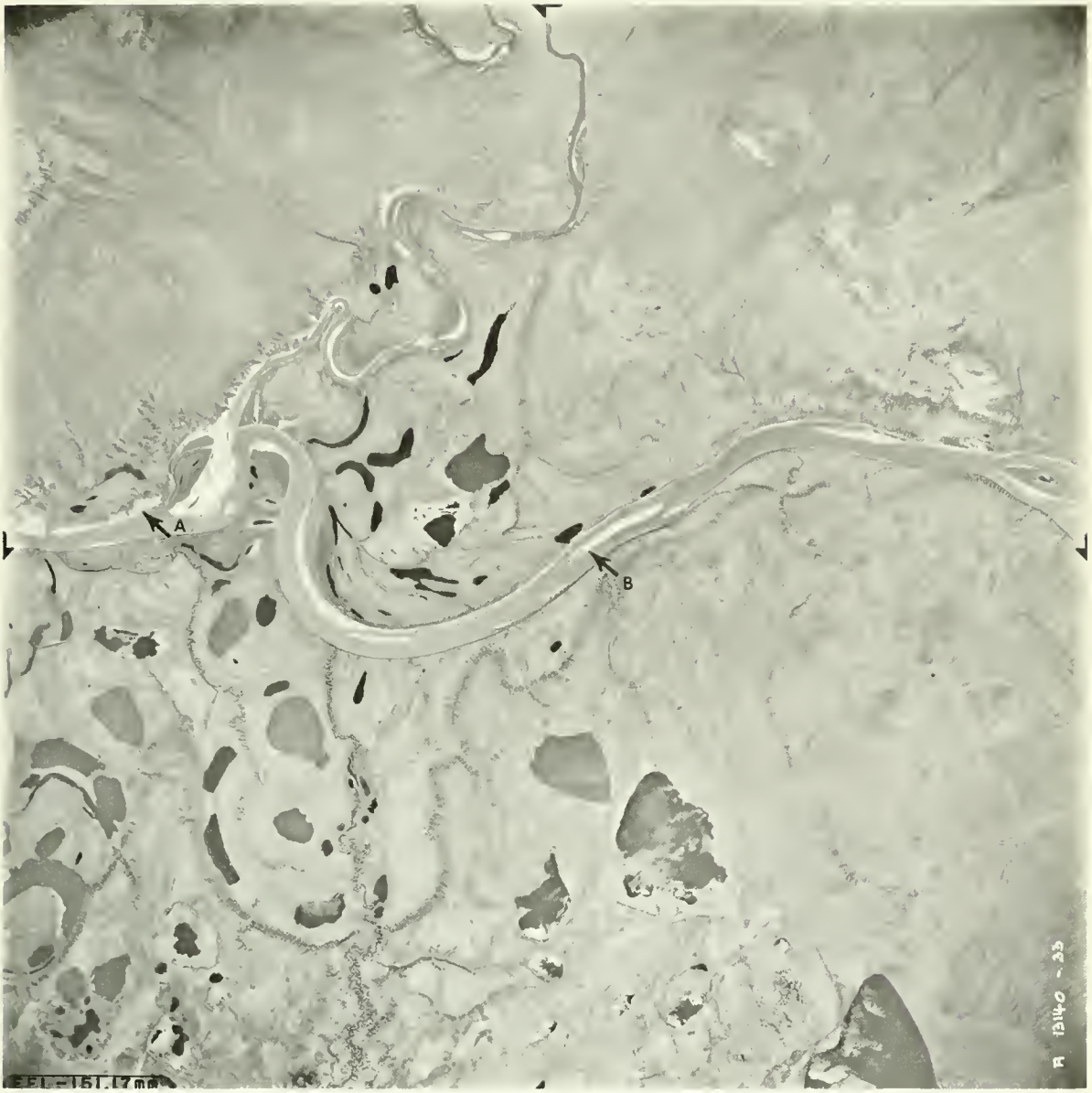

Fig. 2. Junction of Old Crow and Porcupine rivers. Second sandbar east of Old Crow village (A) in Porcupine River is site of landing strip and temporary camp (B). Air Photo Division—Energy, Mines, and Resources—Canadian Government air photo A 13140-33.

stream from town, where the airstrip was located in earlier years and was used during the early part of the summer of 1970. It was usable only during low-water stages of the river and is periodically flooded, even during the summer, by floods related to heavy rainfall.

Winter seismic trails cross the Blow River Pass into Old Crow Flats from the northeast from the Arctic slope east of the Barn Mountains. A winter road was bladed across the Eagle Plains and into Old Crow village during the winter of 1969-70, from the Demster Highway through the Ogilvie Range. It connects to Dawson and roads to the south.

Most aircraft of the region are based at Inuvik, and both wheeled and float-equipped planes are available for service and charter. Inuvik is the local center for shipping and connections to regions outside the lower Mackenzie River valley and delta region. It is the major supply point for much of the northern Yukon and adjacent Northwest Territories, and most items required can be purchased through suppliers there.

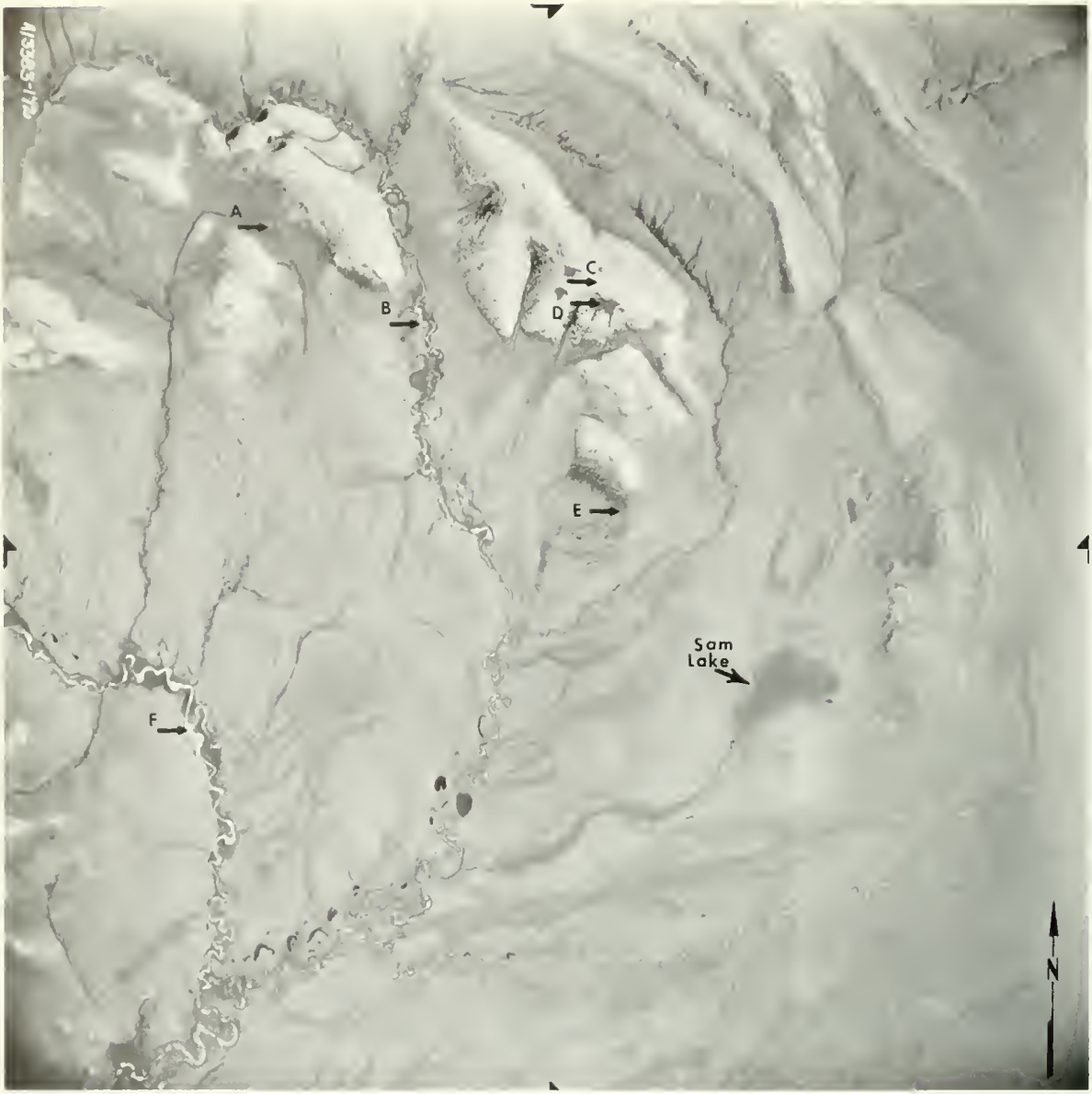

FIG. 3. Sam Lake, northeast portion of Old Crow Flats, and Barn Mountains, with Black Fox Creek at the left and its major tributary, Dog Creek, in the center. Collecting localities: A=55; B=59; C=58; D=57; E=60; F=56. Air Photo Division—Energy, Mines, and Resources—Canadian Government air photo A 13383-172.

TOPOGRAPHY

The area includes the generally mountainous to hilly region of the British Mountains and Barn Mountains, the western foothills of the Richardson Mountains, the western part of the narrow Arctic coastal plain of Canada, and the flat, marshy, Old Crow Flats (Fig. 5).

OLD CROW FLATS

Old Crow Flats covers a wide area of low relief extending south from the British Mountains and west from the Driftwood Mountains to the Old Crow Range, north of the village of Old Crow. It is approximately 40 miles across north-south and 50 miles across east-west. The entire flat is between 800 and 1,400 feet above sea level and gently slopes to the south into the Old Crow River, which drains the lake-studded flats into the Porcupine River through a gap at the eastern end of the Old Crow Range.

The flats are covered with small lakes and poorly drained marsh, much of the latter show-

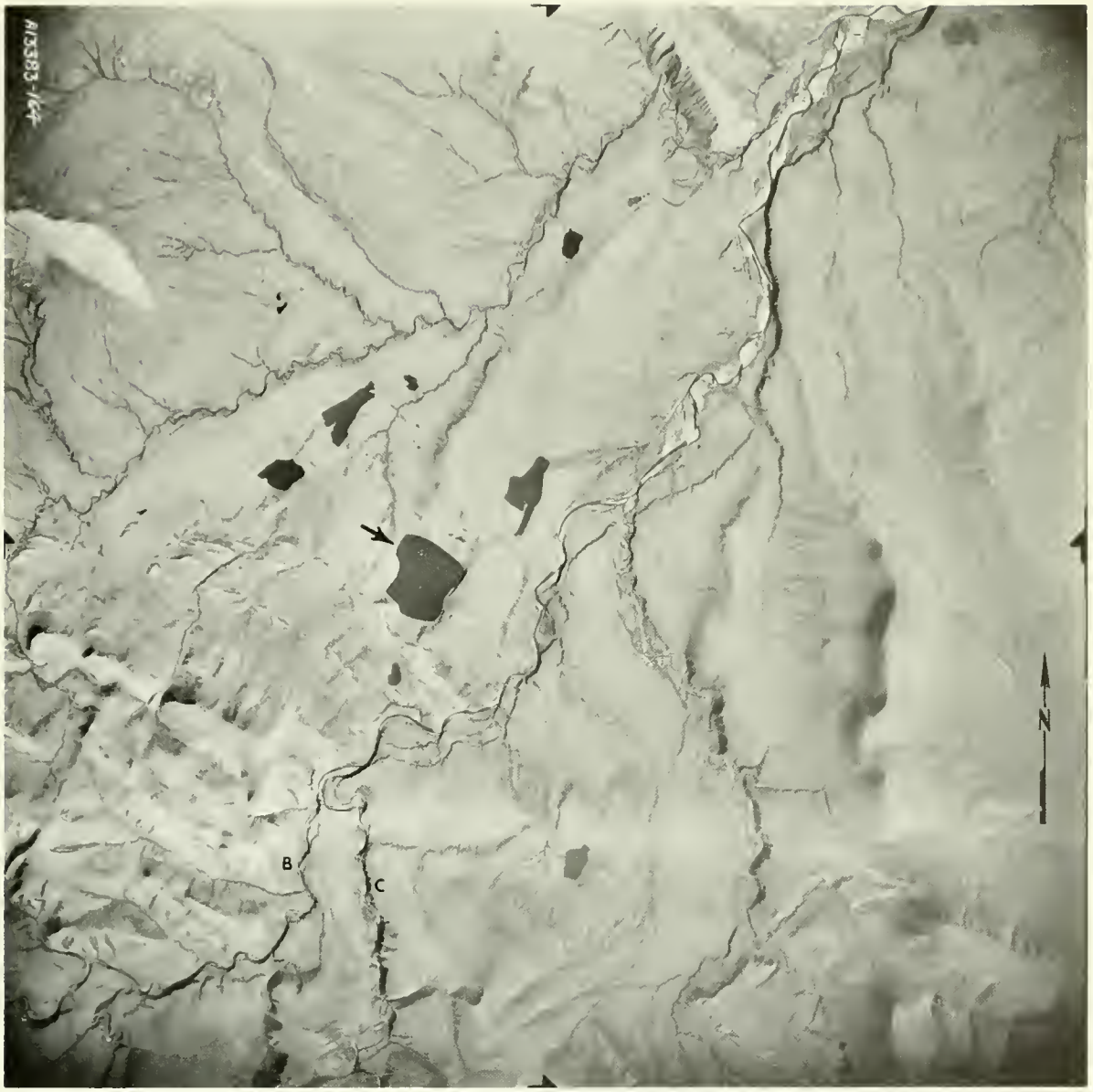

Fig. 4. Trout Lake, north of the junction of Canoe (C) and Babbage rivers (B). Arrow marks collecting locality on Trout Lake. Air Photo Division—Energy, Mines, and Resources—Canadian Government air photo A 13383-164.

ing excellent patterned-ground development. Individual lakes range from small ponds up to lakes 8 to 10 miles across. Most of the lakes are marsh-bordered, and only a few have beach development at all. Limited beaches are common at the southern end of the lakes, evidence of dominantly north winds.

Several of the major streams such as Black Fox Creek, Timber Creek, and Old Crow River which drain across the flats, are entrenched into the fine-grained fluvial sediments and lake clay and silt that form the flats. Entrenchment increases toward the south into the major Old Crow River drainage where streams may be as much as 50 to 60 feet below the general flat upper surface. Streams in the interior of the flats may be entrenched 10 feet, but in the outer peripheral areas entrenchment of 4 or 5 feet is typical. Major streams entering from the mountain slopes have produced belts of gravel, spread by the meandering streams. These are tree-covered with white spruce and cottonwood trees in the central and southern part of the area, but are willow-covered and barren, meander-scarred plains in the peripheral areas. Old Crow Flats is an area of easy winter road development, but

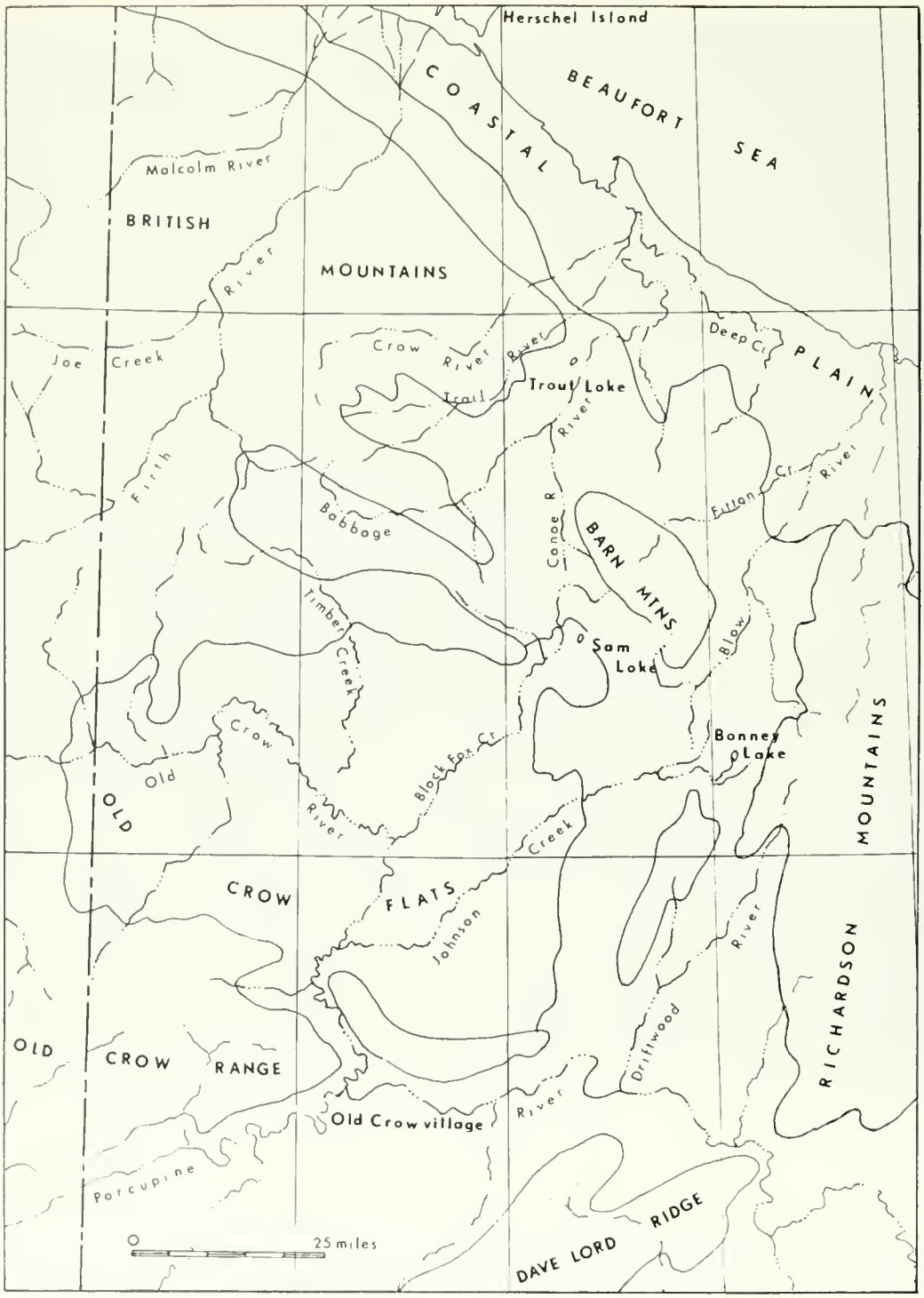

FIG. 5. Map of collected area in northern Yukon.

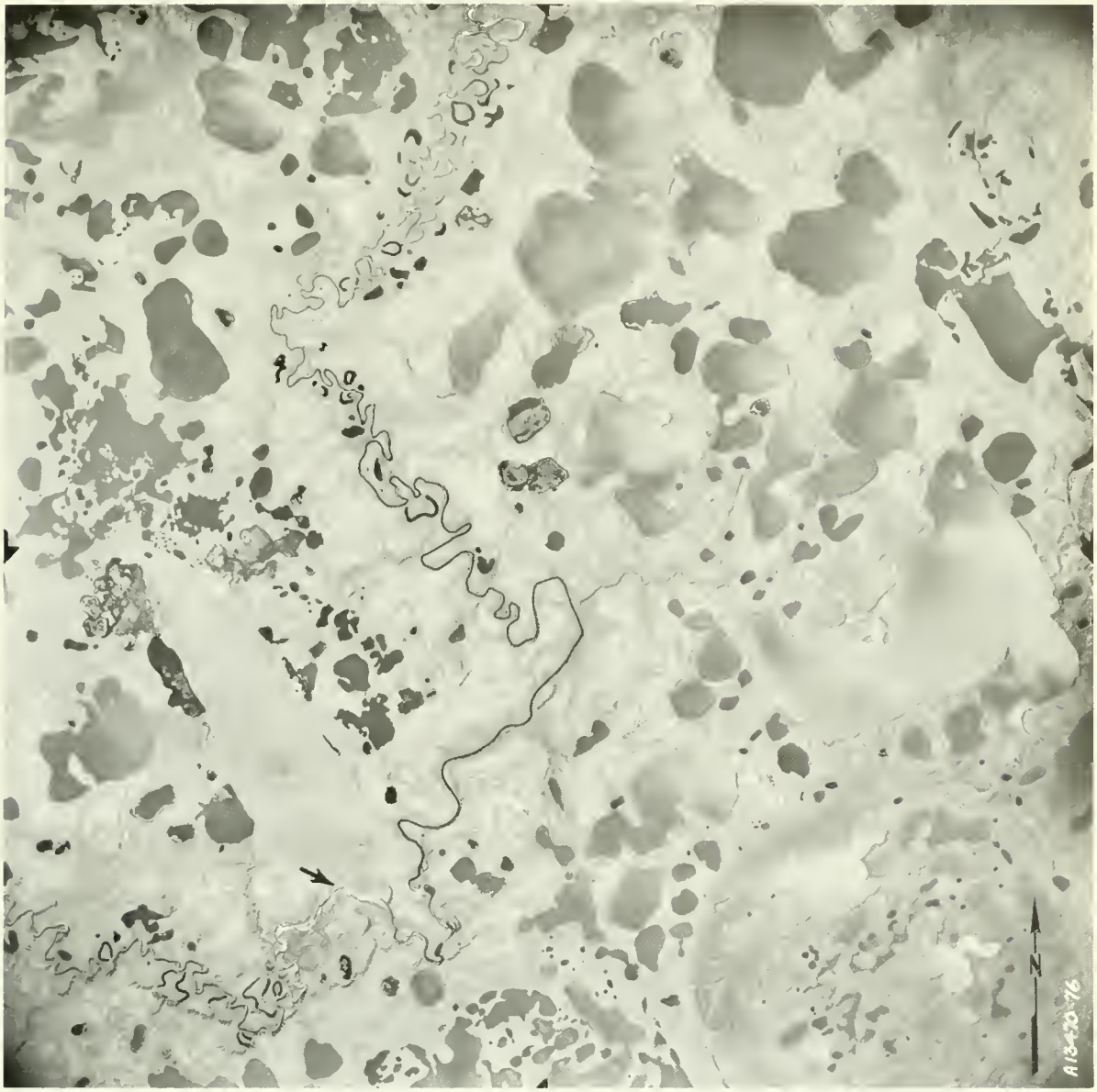

Fig. 6. Old Crow Flats, along Timber Creek showing angular lakes with about the same directional development as the ridge at left. Arrow marks collecting site 67. Air Photo Division—Energy, Mines, and Resources—Canadian Government air photo A 13470-76.

a bottomless bog area during summer, and for much of the year, it is a barrier to overland movement.

Several low "islands" rise above the general marshy level of the flats (Fig. 6). These are bedrock exposures of either Lisburne Limestone, Kayak Shale or of the younger lower sandstones of the Cretaceous sequence. These rocks are folded and appear to be overlain unconformably by the much younger lake silts and clays of the flats. The islands rise as much as 400 to 500 feet above the general level of the flats. Minor ice-shoved gravel beaches produce limited dry-ground ridges 5 to 15 feet high along the shores of some lakes.

Lakes of the flats occur generally below the 1000-foot contour, where the flats have a slope of only a few feet per mile. These lakes range from angular rectangular to rounded and many show a distinct lineation with a northwest-southeast trend and an even more pronounced northeast-southwest one. Such rectangular outline is particularly shown well in the southeastern and northwestern quarters of the flats, but is also evident in the northeastern part. The northwest-southeast trend is parallel to fold

trends in the hills in the southern margin of the British Mountains and to the folded rocks in the islands within the flats. One island, on Timber Creek in the southwestern part of the Blow River 1:250,000 quadrangle, shows the pattern and relationship fairly well. The sides are also parallel and normal to the long axis of the Old Crow Flats basin and could be joint controlled in the fractured permafrost in the continuing subsidence in the basin.

Sequences of lake-filling and destruction show in the patterned ground and marshes of the flats. Some of the shallow lakes have obviously filled with marsh plants and are now virtually destroyed. In some, the patterned ground is now only a vague ghost in the tussock and willow tundra, particularly around the higher ground of the periphery of the flats.

There is some suggestion that the Old Crow Flats basin is still actively undergoing minor subsidence along the trough, for lakes away from the trough appear to have been tilted slightly toward the northwest-southeast axis of the basin, with abandoned shorelines on the exterior basin side and encroaching shorelines on the interior side.

BARN MOUNTAINS

The Barn Mountains (Fig. 7) are a relatively low, north-south trending range in the north-

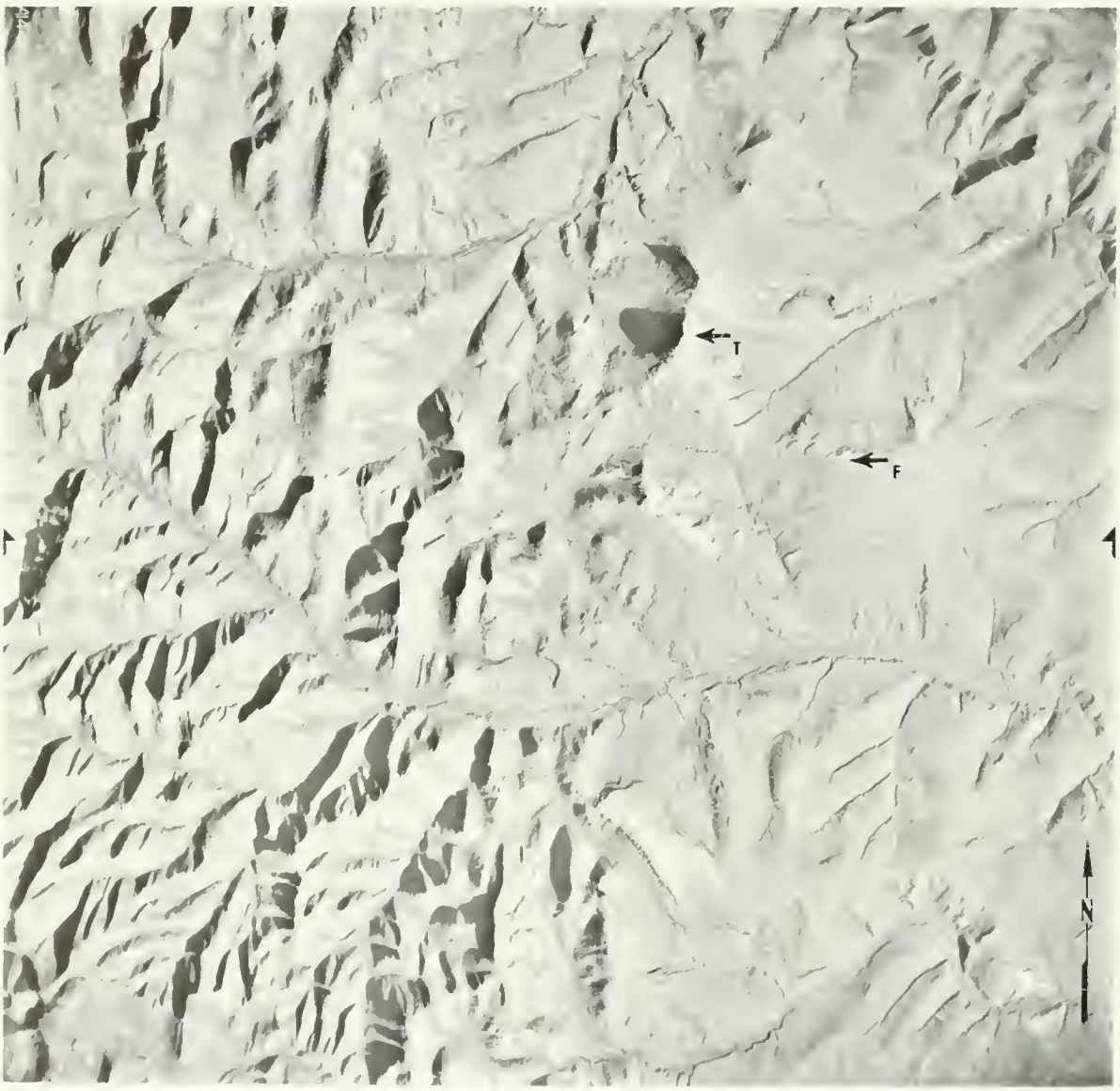

FIG. 7. Barn Mountains, east side, with western tributaries of Blow River, and with Twin Peaks (T), and Mt. Fitton (F), near right center. Air Photo Division—Energy, Mines, and Resources—Canadian Government air photo A 14406-66.

eastern side of the area of concern, west of the Blow River and the northern end of the Richardson Mountains, and northeast of Old Crow Flats. They rise to approximately 3500 feet, 2000 feet above Old Crow Flats to the southwest, and above Blow River valley to the east. The Barn Mountains are bordered on the northwestern and northern side by low hills that form a foothill belt with the Arctic coastal plain.

The Barn Mountains are rolling, occasionally angular, barren hills and low-rounded mountains, carved on older fractured rocks which break into angular talus and fragmental rubble that blanket the slopes in fine debris. There is little tundra development on the generally steeper rock-strewn slopes. Several streams cut or nearly transect the range so that the mountains consist of essentially three separate masses: one south of the headwaters of Boulder Creek, a central mass between Boulder Creek and the northern one in the headwaters of Anker Creek. All three masses rise to approximately the same exhumed, warped, peneplain surface. Highest points in the range are generally concordant at approximately 3000 feet, but one peak 3506 feet high occurs in the southern part of the central area, at the head of Boulder Creek.

Slopes drop off moderately fast along the eastern side of the elongate triangular range, with valleys developing on softer shale close to the older more resistant rocks. Slopes of the western side are less steep, partially because of an overlapping sequence of Paleozoic limestone which allows development of strong cuestas on the alternating softer and harder beds. The softer pre- and post-Lisburne shales erode to form strike valleys flanking the inward facing Lisburne cuesta (facing toward the core of the Barn Mountains).

The Barn Mountains are approximately 16 miles long and 10 miles wide at their widest on the northern part. They taper southward to only a mile across near their southern tip north of the major bend of the Blow River.

British Mountains

The British Mountains are an east-west trending range which is an eastward continuation of the Romanzov Mountains of the Brooks Range complex of Alaska. They are flanked by a series of moderately low disconnected foothills on the north and south, the former of which are termed the Buckland Hills. The British Mountains are bounded on the south by Old Crow Flats, with a series of isolated partially disconnected hills and ridges of Paleozoic and Mesozoic rocks at the transition.

British Mountains rise to a summit level of approximately 3500 feet in the eastern part, but to more mountainous expression and elevations of as much as 5429 feet in the central part of the belt near the Alaskan boundary, in peaks between the Firth and Malcolm rivers. The inner margin of the Arctic coastal plain on the north and Old Crow Flats on the south are both at elevations of approximately 1500 feet, giving the mountains a relief of approximately 2000 feet.

At the Alaska-Yukon boundary the range is approximately 50 miles wide, but it gradually narrows until it is only 25 to 30 miles wide in the vicinity of the Babbage River, at its eastern end, including some of the small outlying dissociated foothill ranges.

The British Mountains are cut into segments by the Malcolm River, Firth River (Fig. 8), and, at the eastern end, by tributaries of the Babbage River. Broad passes between the headwaters of Thomas and Timber Creek from the south, with the Firth River on the north, functioned as one of the main north-south accessways in the western part of the range. The broad Babbage River valley and Dog Creek and Timber Creek passes also offer relatively low elevation accessways around the eastern part of the range.

General summit levels of the range plunge eastward, perhaps as the generalized surface of an exhumed peneplain at the base of the upper Triassic. Summit-level erosional surfaces appear to be at approximately 5500 feet in the western end, approximately 4000 feet in the central part, and approximately 3000 feet in the area of the Babbage River at the eastern end of the range.

Local topography in the western part of the mountains is often precipitous, with sharp divides and cliff-strewn slopes. In the area east of the Firth River, however, slopes are more gentle and summits are often rounded with a generally subdued topography. Chert and quartzite ridges often show sharp divides, but the dominantly softer rocks erode to less expressive forms.

Arctic Coastal Plain

The Arctic coastal plain (Fig. 9) stretches southward from the margin of the Beaufort Sea to the northern flanks of the Barn and British mountains and a foothill belt, sometimes referred to as the Arctic Plateau or the Buckland Hills, in the western part of the British Mountains. The coastal plain is a region of low relief, sloping from 1000 to 1500 feet along the mountains to an elevation of less than 500 feet at the base of the piedmont only 5 to 10 miles from the mountains. The plain surface has even a much lower gradient in the outer part of the

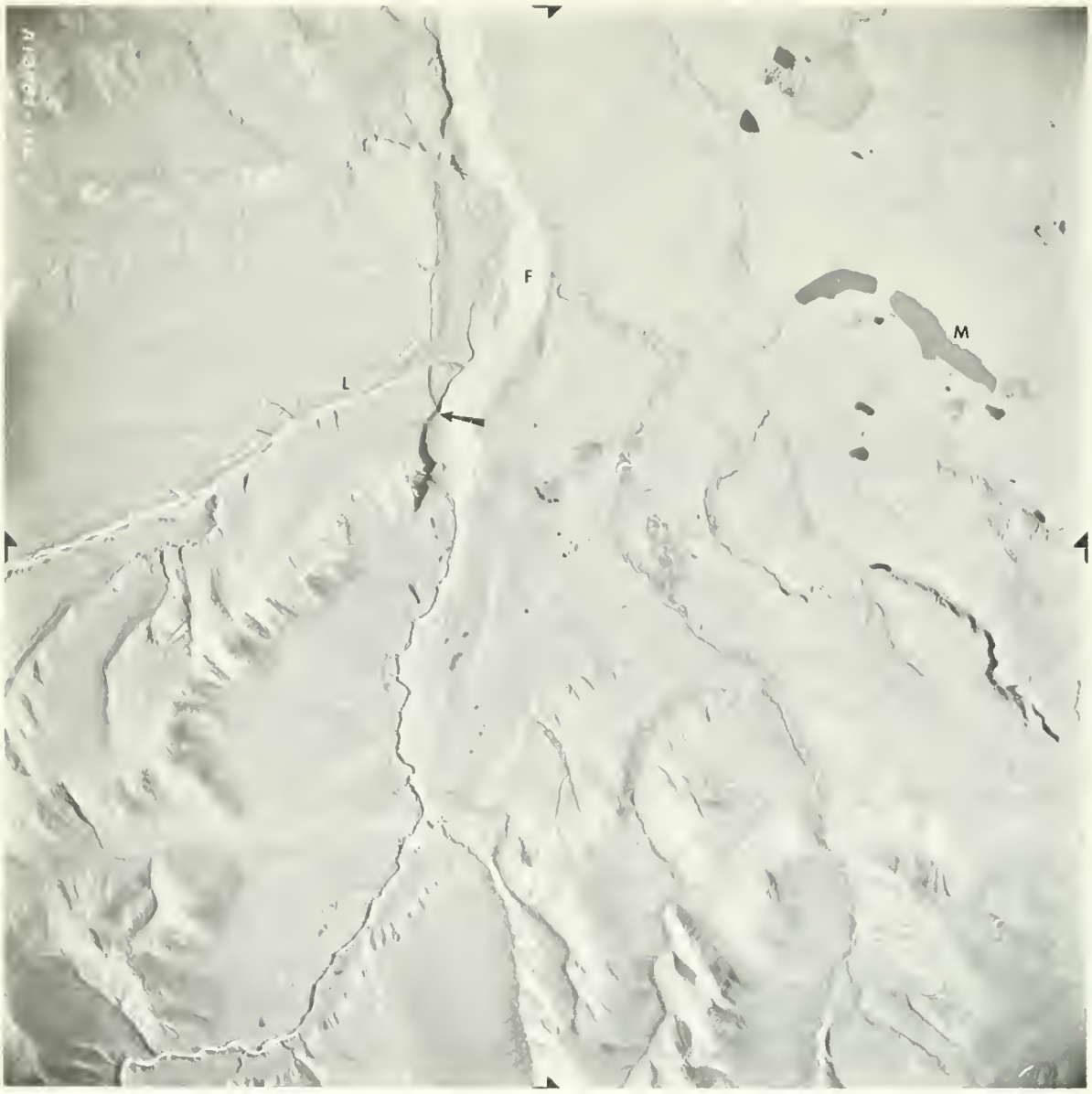

FIG. 8. Firth River (F), along the coastal plain, 10 to 15 miles south of the Beaufort Sea, at its juncture with Loney Creek. Arrow indicates collection locality 6 upstream from Loney Creek (L) and west of McNeish Lake (M). Air Photo Division—Energy, Mines, and Resources—Canadian Government air photo A 13751-116.

plain. Three divisions can thus be recognized in the plain: an inner piedmont, an intermediate zone where fluvial processes are still dominant, and an outer zone where accretionary coastline processes dominate.

The inner piedmont slopes the steepest and is a region of pediment development over the soft Mesozoic shales and sandstones. Locally, the surface slopes approximately 100 feet per mile, or even steeper, in the immediate foothill belt, and is less steep in the outer regions. Slopes in the intermediate zone are usually less than 25 to 50 feet per mile and are covered pediment slopes with gravel and sand blanketing the beveled, slightly folded, softer, younger rocks. The slope of the outermost zone is even less yet terminates in the embayed coastline-sea cliff development of the shoreline.

The coastal plain is a region where broad deltas are developing from each of the major streams, such as the Malcolm, Firth, Babbage, and Blow rivers. The Firth and Malcolm rivers are producing deltas typical of steep headlands with smooth fronts and multidistributary fanning channels. The Babbage River, on the other hand, is producing a delta which is a miniature of the

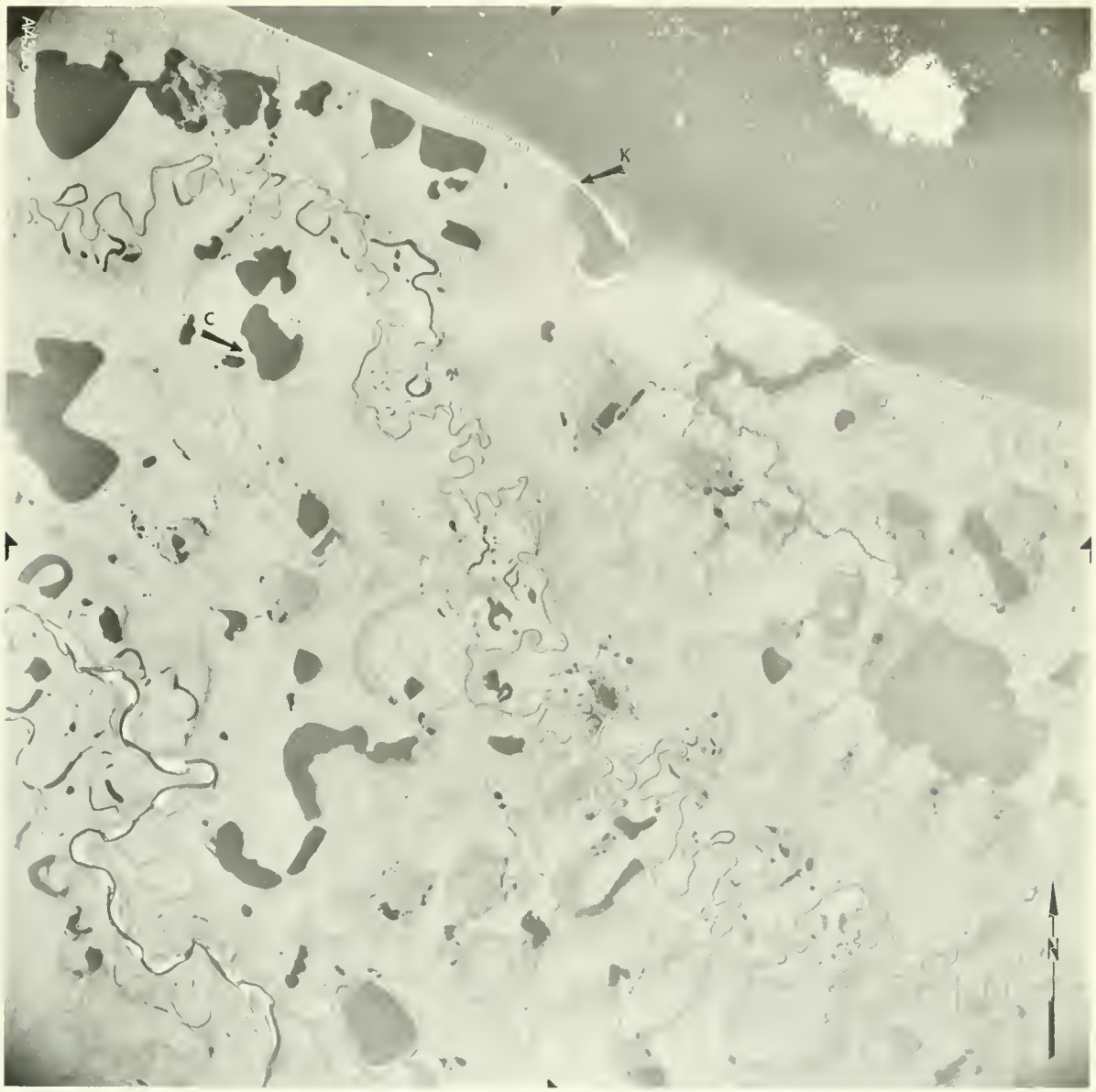

Fig. 9. Arctic coastal plain, Beaufort Sea, and King Point (K), along the lower reaches of Deep Creek and Babbage River. Collecting locality 13 (C). Air Photo Division—Energy, Mines, and Resources—Canadian Government air photo A 14363-55.

Mackenzie River to the east, filling an estuary between moderately high protecting ridges. The Blow River is emptying onto the flank of the Mackenzie delta and is producing much the same general topographic pattern as seen on the larger structure.

Lakes are a common feature of the eastern part of the outer, lower coastal plain. In general these are shallow, muskeg-bordered lakes with little through-flowing water. Most appear to be kettles or the result of melting ice, with a few related to abandoned channels of the major streams as the latter have shifted their discharge channels near the mountain front. A few of these lakes would be serviceable bases for field parties. In the west, McNeish Lake, east of the Firth River, is deep enough and ice-free long enough to function as a campsite in the late summer. Most of the lakes are not usable, however, because they are surrounded by marsh and soft ground.

Lakes are not common on the upper slopes of the plain, but Trout Lake and the small lake to the north are deep enough and large enough to be serviceable for float plane-based operations. These appear to be ice-melt lakes, possibly even

plunge-pool lakes in the ancient surface of the Babbage drainage.

Entrenchment of streams below the general tundra surface is typical of all the streams draining northward from the British Mountains and Barn Mountains into the coastal plain. These major streams are entrenched not only into their own debris, but into the underlying bedrock as well. For example, the Babbage River is entrenched 60 to 70 feet below the general pediment surface on Jurassic Shale near Trout Lake. The amount of entrenchment decreases coastward, so that halfway across the 25-mile wide plain, it is entrenched only 10 to 15 feet. The degree of entrenchment varies somewhat in the outer reaches of the river, but generally is less than 3 to 5 feet where the depositional surface of the delta begins 4 or 5 miles from the shore.

The Firth River and other more directly emptying steeper streams show the same general degree of entrenchment, apparently related to uplift of the land mass. The Firth River cuts across vertical slate and quartzite near the coastal plain border 20 miles upstream from the shore and is entrenched 40 to 50 feet below the general sloping plain level. Its banks step down in a series of spectacularly developed, cut bedrock terraces. It is well entrenched for approximately 10 miles of the inner and medial parts of the plains, but begins to fan and develop an intricate lobate delta in the outer 10 to 15 miles of its course. It is entrenched only 2 or 3 feet throughout most of the lower gradient part of its coastal plain course.

Four distinct terraces are recognizable on most major streams, with the lower two as the most prominent and with deepest entrenchment. The vertical-walled entrenchment of the Malcolm, Firth, and Babbage rivers into bedrock cut terraces is particularly striking at the mountain front-coastal plain boundary.

Deposits of the Firth River terminate in a rounded, lobate or arcuate deltaic coastline, with an offshore lagoon and barrier island sequence, a suggestion of moderately active regression and energy dissipation along the shoreline. The Malcolm River shows an almost identical pattern and has even a more spectacularly fanning delta, terminating in the typical lobate to crescentic seaward margin, with a bordering lagoon and an offshore barrier island sequence, named Numatak Spit.

Abandoned beaches mark the uplands of the coastal plain, scribing the flanks of the British Mountains to elevations of 700 to 800 feet. These appear to be only moderate-energy beaches of relatively short still-stand because of the immaturity of the beach clastics, as well as shallowness of indentation and poor development of sea cliffs. Some of the high levels may be kamelike features developed where mountain streams banked against Pleistocene sea ice from offshore or against a lobe of continental ice from the Mackenzie River.

The coastal plain varies from 6 or 7 miles wide at its western development, north of the British Mountains west of the Malcolm River, to a broad plain 30 to 55 miles wide north of the Barns Mountains, west of the Blow River valley. It narrows again to the east around the northern end of the Richardson Mountains where there is only a minimum plain between the mountains and the southwestern margin of the Mackenzie delta.

Buckland and Babbage Hills

The Buckland Hills are on the north flank of the British Mountains. The term Babbage Hills is applied to the continuation of these mainly dissociated hills of Late Paleozoic and Cretaceous rocks in the vicinity of the headwaters of the Babbage River.

On the southern side of the British Mountains the hills are commonly cuestas or unbreached anticlinal ridges of Lisburne Limestone from which the softer Jurassic and Triassic beds have been stripped. Cuestas of Cretaceous rocks in the structural saddle between the Barn and British mountains also form features of relief that rise above the softer shale valleys as distinct linear features. Similar dissociated hills on the northern side of the British Mountains are on outliers of older Neruokpuk rocks and, in the eastern part, on cuestas of Cretaceous sandstone in the Crow River, Trout Lake, and Sleepy Mountain region.

Driftwood Mountains

The Driftwood Mountains are an elongate north-south range along the east side of Old Crow Flats, south of the Barn Mountains. They are cored by ragged-weathering Lower Paleozoic chert and siliceous shale, surrounded by gentle cuestas of Upper Paleozoic and Mesozoic rocks. They form a series of hills approximately 12 miles wide and 25 miles long which rise to an elevation of slightly over 3000 feet, approximately 1500 feet above Old Crow Flats on the west and 2000 feet above Driftwood River on the southeast. They are the southwestern end of a series of hills leading southwest from the main Richardson Mountains east of Bonney Lake.

WEATHER

Weather experienced during the summer of 1970 can be subdivided into basic patterns or periods. During the month of June, at least from the time we arrived at Sam Lake area until the first week in July, the weather was moderately clear all the time, with only three one-day periods when fieldwork was not possible because of weather. The days were bright and clear, with a consistent wind from the north or northeast.

Wind exhibited a diurnal variation related apparently to the differences in temperature between Old Crow Flats and the north slope and Arctic coastal plain. During the afternoon, following warming of the Old Crow Flats, air rose over the flats and pulled cool air from the north, producing moderately strong winds from approximately noon until 1:00 to 2:00 a.m. During the period from 2:00 a.m. until late morning, the air was usually moderately calm.

The several short-duration storms in June blew in from the northeast with wind-driven rain, with the exception of one storm which blew in from the northwest. In general the weather pattern was from northwest to southeast or from west to east for the entre summer.

During June the temperatures on the valley bottoms and around Sam Lake were approximately 40° to 50° during low sunlight periods at night and during the windy part of the day, but warmed to 60° to 70° during the calm part of the day. A maximum of 80° occurred during a still period during the period of 24-hour sun in late June.

With the disappearance of sea ice from nearshore in the Beaufort Sea in mid-July, the general weather pattern changed. For two weeks during early July the wind was most commonly from the south, off Old Crow Flats, with several intense thundershowers visible on most afternoons, both in the flats to the south and over the higher part of the British Mountains to the west. This general pattern held until approximately mid-July when the major winds again came from the north and northeast, bringing thick persistent banks of sea fog onto the northern slope and into the lower valleys of the mountains. Only at night did fog reach onto the southern part of the mountains in areas west of the major drainage through Blow River valley. Occasionally fog would accumulate in the Old Crow Flats area, but commonly the Sam Lake area remained fog-free even though surrounding areas were blanketed. Bonney (Bonnet) Lake was commonly fog-blanketed, while areas to the west were moderately clear. Trout Lake and the lower end of the Babbage River valley were often fog-blanketed during late July and early August.

Temperatures remained in the 60s and 70s during the days in the area around Sam Lake, and only when cold winds blew off the sea to the north did temperatures in the mountains drop much below that of the base camp. Temperatures at night remained near 50° during the early part of July in the base camp area, but dropped into the 30s during the nights of late July and early August. The first frosts occurred July 30 and 31 during a period of calm following a cold north wind.

Weather in late July and early August was decidedly cyclic. Calm wind and bright clear weather was generally followed, usually in less than one day, with high cirrus clouds and increasing winds usually from the south or southwest. Cloud cover increased and winds calmed, usually followed by a warm, steady rain, sometimes for 2 or 3 days. Wind velocity then increased and swung from south to southwest, then west. Patches of broken clouds usually followed with a change of wind from west or northwest into the north or northeast, with some increase in clouds and much increase in local fog on the ridges north of Sam Lake, in Blow Pass and Babbage River Pass, and over the coastal plain. This usually was followed by clearing and strong northeasterly wind, with later calming and beginning of bright, clear weather again. The entire cycle usually took from 3 to 5 days to pass.

STRATIGRAPHY

Rocks of the region range in age from Late Precambrian(?) to Upper Cretaceous, with Tertiary(?) and Quaternary sediments over the more consolidated part of the section. The section breaks into four broad sequences of rocks: an older Precambrain to Devonian(?) strongly folded argillaceous and cherty section included in the Neruokpuk and equivalent Road River formations (Martin, 1959; Norford, 1964; Norris *et al.*, 1963; Reed, 1968); an intermediate Upper

Paleozoic section which includes a basal clastic sequence of Devonian and Mississippian age overlain by a carbonate sequence, the Lisburne Limestone, of Mississippian and Pennsylvanian age; and an upper sequence of clastic Jurassic and Cretaceous rocks including the Kingak Shale and unnamed Cretaceous formations (Jeletzky, 1961; Mountjoy, 1967b). A fourth sequence of Permian and Triassic rocks is exposed in the western part of the area (Mountjoy, 1967a) between the Lisburne Limestone and the Jurassic Kingak Shale. A total thickness of approximately 40,000 feet of beds is present in the area (Fig. 10).

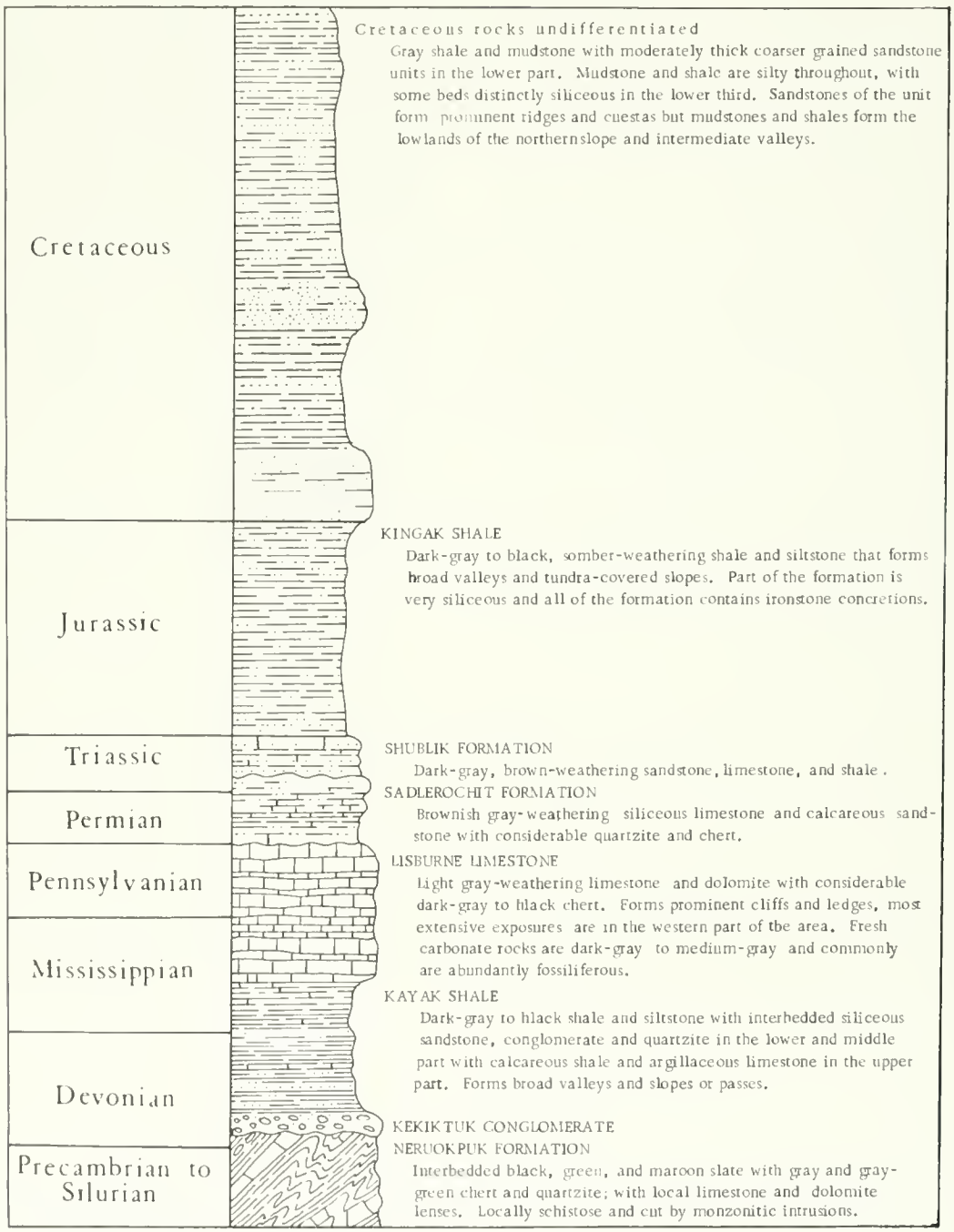
Cretaceous
Jurassic
Triassic
Permian
Pennsylvanian
Mississippian
Devonian
Precambrian to Silurian
Cretaceous rocks undifferentiated
Gray shale and mudstone with moderately thick coarser grained sandstone units in the lower part. Mudstone and shale are silty throughout, with some beds distinctly siliceous in the lower third. Sandstones of the unit form prominent ridges and cuestas but mudstones and shales form the lowlands of the northern slope and intermediate valleys.
KINGAK SHALE
Dark-gray to black, somber-weathering shale and siltstone that forms broad valleys and tundra-covered slopes. Part of the formation is very siliceous and all of the formation contains ironstone concretions.
SHUBLIK FORMATION
Dark-gray, brown-weathering sandstone, limestone, and shale.
SADLEROCHIT FORMATION
Brownish gray-weathering siliceous limestone and calcareous sandstone with considerable quartzite and chert.
LISBURNE LIMESTONE
Light gray-weathering limestone and dolomite with considerable dark-gray to black chert. Forms prominent cliffs and ledges, most extensive exposures are in the western part of the area. Fresh carbonate rocks are dark-gray to medium-gray and commonly are abundantly fossiliferous.
KAYAK SHALE
Dark-gray to black shale and siltstone with interbedded siliceous sandstone, conglomerate and quartzite in the lower and middle part with calcareous shale and argillaceous limestone in the upper part. Forms broad valleys and slopes or passes.
KEKIKTUK CONGLOMERATE
NERUOKPUK FORMATION
Interbedded black, green, and maroon slate with gray and gray-green chert and quartzite; with local limestone and dolomite lenses. Locally schistose and cut by monzonitic intrusions.

FIG. 10. Geological section in northern Yukon.

VEGETATION

The general aspect of northern Yukon is dominated by vegetation of low relief, i.e., tundra. The hills and valleys have the look of a well-tended golf course (Fig. 11). The vegetation is not uniform, however, it varies in cover and in composition. The major vegetative control appears to be the amount of moisture that is available. Substrate differences appear to influence the water supply directly, and thus the plant cover indirectly. The limestone, shale, sandstone, and siliceous conglomerates, slates, and schists of the lower, rounded mountains generally lack the more lush vegetation of the bajadas, wet meadows, and stream courses of lower elevations. Rock stripes, boulder patches, and rock outcrops appear at first glance to be barren of higher plants. They are vegetated by a sparse cover of plants widely spaced. Even the lowlands display a mosaic pattern in the green mantle of the land. Frost-heaved patches of gravel of irregular shape produce a varied pattern in the tundra. The swales where water drains slowly over the surface are bright green compared to the slopes alongside them. Polygonal patterns appear here and there in the tundra, apparently always associated with poorly drained sites. The lower trenches of most polygons are moist or have standing water in them and frequently are more lushly vegetated than the surrounding area. Tall vegetation is present only along the streams, where willows and an occasional cottonwood stand a few feet above the surface. Southward along the upper reaches of the drainage of the Old Crow and rarely in the headwaters of the streams which drain to the Arctic Sea, there occurs a depauperate assemblage of the Boreal Forest, chiefly along stream courses, and along some south facing slopes. This forest extends to about 69° 15′ N along the Firth River, at approximately 140° 25′ W. Eastward, however, the forest does not extend that far north, reaching only to about 68° 39′ N along Spruce Creek, a tributary of the Canoe River, at approximately 138° 43′ W. The trees reach their best development in the mountain system on south facing slopes near the bases of low rounded hills. In the Old Crow Flats there has developed a parkland tundra or taiga, the interspaces of which is dominated by a heathland of dwarf birch, willows, and other shrubs. In some places the woodland is really quite dense, the trees reaching a height of up to 25-30 feet and a few inches in diameter.

Fig. 11. Northwestward from approximately 58°32′ N; 138°27′ W, along westward dipping cuestas of Lisburne Limestone, at the northwest edge of the Barn Mountains, in the headwaters of Wood Creek. Low vegetated valleys are in the Kayak shale, in part in fault-repeated sections. Tussock and alpine tundra and heathlands.

Lakes dot the land in the Old Crow Flats but are less common elsewhere; in fact, there are very few lakes of any consequence in the mountains. Numerous lakes, most lacking higher plant life, occur on the coastal plain of the north slope. Thus, aquatic vegetation is best represented in the Old Crow drainage system.

Streamsides and Bars

The effects of streams seldom reach far from active running water. However, since the streams tend to be braided, at least in the lower reaches, the effect is often more broadly felt. Willows of one to several species dominate the banks (Fig. 12 and 13). Where meanders develop there may be considerable development of willoy dominated vegetation (Fig. 14 and 15). The height of these riparian plants varies from one foot to ten or fifteen, or less commonly to twenty feet. The larger plants are the willow, *Salix alaxensis*, with densely hairy branchlets. However, the cottonwood, *Populus balsamifera*, is sometimes present (Fig. 16). Neither of these plants reach far from the streamside. As soon as the riparian boundary is exceeded, there is no more *Salix alaxensis*. Certainly *Salix alaxensis* is the abundant, tall willow species along all of the drainages, from high elevations down to very low ones, except, of course, in the Old Crow River area where other species become important, but even there *Salix alaxensis* continues as one of the dominant species.

Other species of willow grow along the drainages and grade in height backward from the abundant moisture of the river or stream into the drier heath or tussock tundra along the margins. Here and there the alder, *Alnus crispa*, grows tall enough to add to the thicket along the drainages and in some places such as along the Firth River, at its junction with Muskeg Creek, the alder forms a part of the heath vegetation some distance back from the bank (Fig. 17). Similar extensive growth of alder occurs along the lower portions of the Blow River and in the Old Crow Flats where river bars are formed which do not receive an annual scouring. Bars which receive annual scouring do not support vascular plants, but are barren throughout the growing season (Fig. 18).

Many plants occur in the openings among the willows lining banks and bars. Here such things as sweet vetch, milk vetch, buttercups,

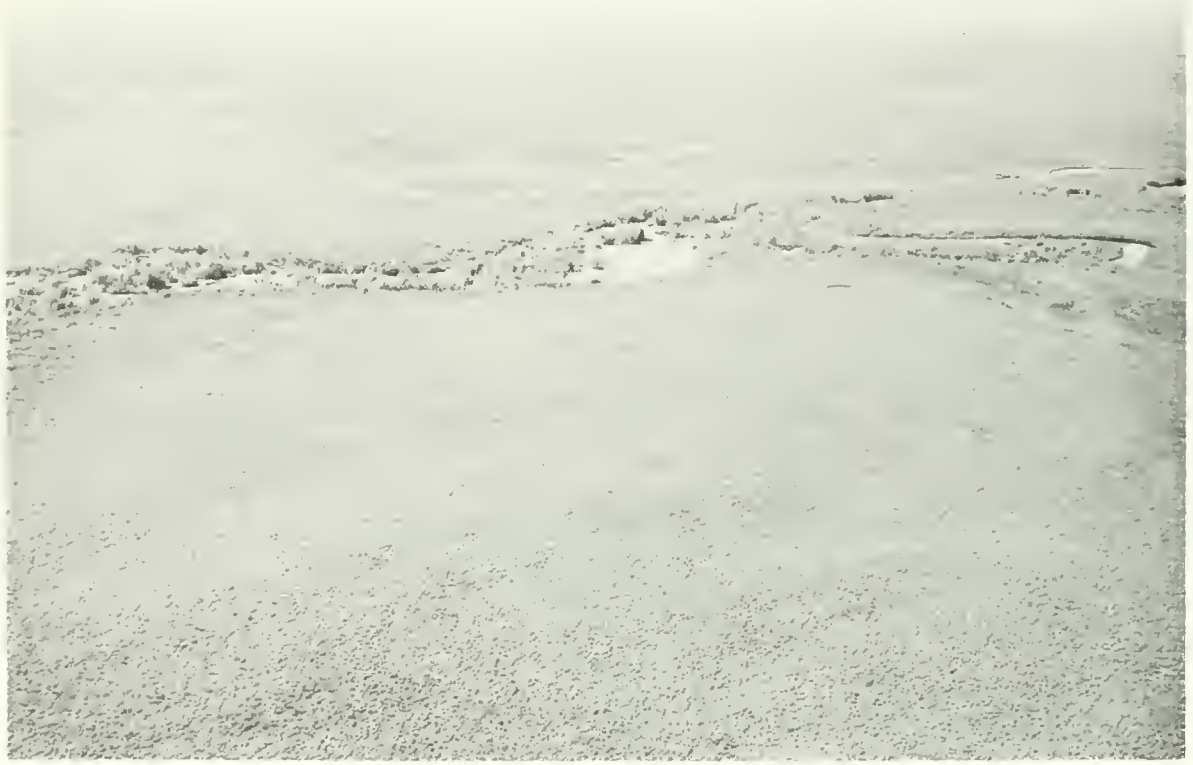

FIG. 12. South across small unnamed creek with gravel meanders and willow margins immediately southeast of Sam Lake at 68°23′ N; 138°38′ W. Broad low country of Old Crow Flats forms the background. The foreground is tussock tundra, with alternating heathlands and tussock tundra in the background.

Fig. 13. Downstream along Spruce Creek from almost the same position as Figure 23, at an elevation of approximately 1000 feet. Jurassic Kingak Shale is exposed in the gully margins.

chickweeds, and other plants grow in profusion adding pink, yellow, and white to the color of the gravel bar vegetation. Poorly drained sites back from the riparian vegetation develop a distinctive cover of plants. *Dryas*, *Empetrum*, *Ledum*, *Arctostaphylos*, *Betula*, *Vaccinium*, (*vitis-idaea*, and *uliginosum*) and *Salix* dominate the community. But secondary species brighten the landscape with shades of yellow (*Arnica* and *Oxytropis*), white and lavender (*Castilleja*), blue (*Mertensia* and *Lupinus*), and pale cream (*Pedicularis capitata*), and pink (*Pedicularis* and *Hedysarum*). The tiny flowers of the miniature plants of *Tofieldia* and *Carex* add to the diversity of flower types, and here and there are the bright pink spikes of bistort and the inconspicuous ones are viviparous bistort. This heath type forms a dark, dull green stripe along the drain-

FIG. 14. Jurassic and Cretaceous sand and shale at the junction of Canoe River with the Babbage River south of Trout Lake, taken from approximately 68°48′ N; 138°45′ W. The river terraces are veneered here and there with a thin blanket of gravel. Tussock tundra (center), heathland (along slopes) and willow dominated bar (foreground).

Fig. 15. Cretaceous shale and sandstone at approximately 68°55′ N; 138°31′ W, along the lower part of the Babbage River where the river has emerged from the British Mountains onto the Coastal Plain. Low country in the background is carved on soft Cretaceous sediments. Willow, alder, and dwarf birch heathland in foreground and along stabilized bar.

age systems in the tundra and can be picked out from some distance by its contrast with the pale or gray green of the tussock tundra (Fig. 19).

Lake Margins

In the tundra, the lakes are generally small and commonly shallow. The margins are frequently occupied by emergent plants. Principal among there are the sedge, *Carex aquatilis*, and the grass, *Arctophila fulva*. The wet meadows at the waters edge are dominated by the cotton grass, *Eriophorum angustifolium*, and back from the waters edge the vegetation is dominated by a thicket of low willows (*Salix*) and birches (*Betula glandulosa*). Interspersed among the

willows and extending into the wet meadows are *Andromeda polifola*, *Cardamine purpurea*, *Pedicularis kanei*, *P. sudetica*, *P. labradorica*, and *Rubus chamaemorus*. The extent of the wet meadow and the willow-birch thicket is controlled by the topography features of the lake basin. Also, the height of the willows and birches is apparently a function of topography and snow depth, with the height of the inner ridge of the lake basin and the height of the snow bank formed adjacent to the ridge limiting shrub height. *Ledum decumbens* and *Empetrum nigrum* fill in between the willows and the birches. In some lakes there is an accumulation of several feet of organic debris along the beaches. The aquatic and semiaquatic plants occupy the organic fill in the same sequence as in lakes which have rocky basins forming the beach. The shallow lake at collecting locality 72 has two organic debris littered beaches (Fig. 20).

Tussock Tundra

Landward from either lakes or streams, there is developed a hummocky tundra which covers more land surface than any other vegetative type. Even here there is much variation in the composition of the vegetation. Near streams and lakes there is a transition from the tallish, lush vegetation characterizing these sites to the hummocky tundra type (Fig. 21 and 22). Slopes along streams are characteristically transitional to tussock tundra also (Fig. 23). The transition may be completely subtle or it may be abrupt. Generally, *Salix alaxensis* gives way abruptly along the wet sites, but the other species of willow which may grow to a height of a few feet along the streams continue to dominate the rounded hummocks of the tundra, but seldom reach a height much above the hummocks. They grow there with *Vaccinium vitis-idaea*, *V. uliginosum*, *Betula glandulosa*, *Dryas integrifolia*, *Arctostaphylos alpina*, *Pedicularis capitata*, *P. labradorica*, *P. kanei*, *Oxytropis maydelliana*, *Cardamine digitata*, *Polygonum bistorta*, and *Carex* species.

In higher, better drained ridges and slopes, the willow hummocks give way to a cotton grass tussock tundra dominated by *Eriophorum vaginatum* and *Carex* species. Shrubs are not lacking in the tussock tundra, but their role is subordinate to the cotton grass. In fact the same species of shrubs outlined for the wetter hummocky tundra occur in the tussock tundra as well.

Fig. 16. Undercut meander bend along Black Fox Creek in the east central part of Old Crow Flat at 139°30' W; 68°07' N at Locality 68. Elevation of about 900 feet. Willow and cottonwood dominated bar, with taiga and heathland in background.

Fig. 17. Southwest across the Firth River to Firth Rock. Collecting locality 15, at 68°47′ N; 140°28′ W and at approximately 1400 feet in elevation is on the gravel bar in the center of the stream. Vegetation in the foreground is on river gravel terraces. Firth Rock is composed mainly of Lisburne Limestone. Firth Rock rises approximately 1000 feet above the river valley. *Salix, Betula, Alnus* heathland and taiga along valley bottom, river bank, and bar.

Swales and moist flats in the tussock tundra appear green and lush by comparison to the well-developed tussock tundra. The green of the sites is due in a large part to the presence of the cotton grass *Eriophorum angustifolium*, and in some places to the presence of the horsetail, *Equisetum arvense*. Where the relief is low and drainage is poor, there is developed a topography made apparent by the presence of polygonal figures in the tundra (Fig. 24 and 25). Each polygon is outlined by a trench, and this is often filled with water or is, at any rate, more moist than the surrounding area. Here grows *Eriophorum angustifolium* and *Carex* species, often in a mass of *Sphagnum*. Other plants in the polygons are *Potentilla palustris*, *Pedicularis* species and *Menyanthes trifoliata*. In drier polygons the trenches often support a community of plants similar to that along a stream channel, i.e., with *Salix, Betula, Empetrum, Ledum*, and *Vaccinium*.

Alpine Tundra

Mountains in the northern Yukon appear pale green to gray or else they are green only in small areas. Talus and rockstripes are often bar-

ren of plants or are occupied by clumps or stripes and patches of *Dryas, Empetrum, Betula,* and *Carex.* Talus slopes are evidently in motion, and vegetation is commonly oriented in stripes with an up-down slope axis (Fig. 26). Ridge tops are characterized by widely spaced plants of *Potentilla uniflora, Draba caesia, D. lactea, Astragalus australis, Oxytropis nigrescens, Saxifraga reflexa, S. tricuspidata, Douglasia arctica, D. ochotensis, Parrya nudicaulis, Phlox sibirica,* and *Eretrichium nanum. Carex, Kobresia, Festuca,* and *Poa* are the principal monocots. Again, density and composition varies, with the most dense vegetation in swales and on north facing slopes. Seeps and springs are densely covered with *Salix, Betula, Empetrum, Dryas,* and *Carex* and numerous herbaceous species. The herbs in the seepy areas are the same as those in wet meadows, i.e., species of *Pedicularis, Cardamine, Anemone, Senecio, Carex, Kobresia, Dodocatheon, Lagotis, Parrya, Polemonium,* and *Myosotis.*

From the specimens collected, it seems that each geological stratum exposed in the alpine tundra supports a distinctive flora. In regions where vegetative cover is well developed, the plants are insulated from the geological formation by organic debris, permanently frozen ground, or by alluvium. Geological control of vegetation is best demonstrated on outcrops of formations on ridge crests and mountain tops where conditions for growth are poor at best. Some species seem to do well on any substrate, regardless of the nature of the stratum. Others occur principally on limestone formations (Figs. 27, 28, 29 and 30), e.g., *Alyssum americanum; Arenaria rossii var. elegans; Braya purpurascens; Carex petricosa; Festuca brachyphylla; F. ovina; Lychnis apetala; L. furcata;* and *Saxifraga caespitosa.* Those which occur most often on slate and schist (Figs. 31 and 32) include: *Arenaria macrocarpa* Pursh; *A. rubella; Douglasia arctica; Saxifraga eschscholtzii;* and *Senecio fuscatus.* On siliceous conglomerate, granite, and sandstone (Figs. 33, 34 and 35), the list of apparently restricted species include *Loiseleuria procumbens; Potentilla elegans;* and *Saussurea angustifolia.* Those which grow primarily on shale (Fig. 30) include: *Saxifraga exilis* and *S. serpyllifolia.* Siliceous conglomerates and sandstones are definitely poorer in species than are the limestones. The shales and schists are intermediate, but the limestones support the greatest number of species in alpine sites.

FIG. 18. At locality 56. During the maximum meltwater Black Fox Creek runs over the exposed gravel in the foreground.

Fig. 19. Southwest along one of the numerous willow-bordered drainages southeast of Sam Lake in a tundra heathland flat which rims the southwestern edge of the Barn Mountains. Photograph is at approximately 68°23′ N; 138°27′ W. Some of the marginal small lakes at the edge of Old Crow Flats show in the background. Helicopter antenna shows toward the left, and an old seismograph trail shows in the foreground. Alternating stripes and patches of *Salix* and *Betula* (dark) and *Eriophorum*, *Carex*, and *Salix* tundra (light) with large areas of tussock tundra along the drainage margin.

BOREAL FOREST

The Boreal Forest is only poorly developed in northern Yukon. Three main types are recognizable, e.g., white spruce stands on south facing slopes, open parkland tundra (i.e., taiga), and riparian woodland. The first type, the spruce woodland on the southern bases of hills (Fig. 36) and on south facing slopes in valleys (Figs. 37 and 38), is distinctive. This woodland is made up of isolated stands which vary in size from a few trees to rather extensive forests. Southward, in Old Crow Flats, the stands on hills tend to become continuous with the parkland tundra and riparian woods (Fig. 39). The species composition in the spruce stands is the same as that of the parkland tundra, differing mainly in the frequency of species encountered. In both the dominant tree species is the white spruce, *Picea glauca*.

The riparian woods (Figs. 40, 41, 42, and 43) are distinct even though they grade into both of the other types of woodland. White spruce is the dominant conifer, and other tree species are represented by white birch, *Betula papyrifera*,

FIG. 20. Unnamed lakes in Old Crow Flat about 16 miles south of Sam Lake. Collecting locality 72 is along the south side of the lake with two developed beaches (A), and 73 is atop the prominent ridge (B) between the two larger lakes.

Fig. 21. Southwestward along broad open valley near the head of Trail River at approximately 68°53′ N; 139°58′ W. Rocks in the background are principally of Lisburne Limestone. Streaks are reflections from the helicopter bubble. Tussock tundra.

Fig. 22. Stream terraces along the Canoe River south of Trout Lake at approximately 68°47′ N; 138°46′ W. Rocks in the foreground are Jurassic shale. Hills in the background are held up by Cretaceous sandstone. Tussock tundra on patterned ground.

FIG. 23. A view looking upstream along Spruce Creek from 68°38′ N; 138°38′ W. Jurassic Kingak Shale forms exposures in the background with the steeply dipping cuesta in the background of Cretaceous sandstones. *Salix* heathland and tussock tundra.

and the cottonwood, *Populus balsamifera*. *Betula glandulosa* and *B. glandulifera* form the understory in the riparian woods, along with *Salix* spp., *Rosa*, *Ledum*, *Empetum*, and *Rhododendron*. Herbaceous streamside components include; *Agropyron macrourum*, *Arabis hirsuta; Arenaria physodes*, *Astragalus alpinus*, *Barbarea orthoceras*, *Castilleja pallida*, *Hedysarum alpinum*, *H. boreale*, *Stellaria longipes*, and *Taraxacum ceratophorum*.

MARITIME VEGETATION

The maritime vegetation is not essentially different from that of the lower delta vegetative types along the northern coast. Beach and spit gravels and sands (Fig. 44 and 45) support plant communities dominated by *Arenaria peploides*, *Alopecurus alpinus*, *Cochlearia officinalis*, *Elymus mollis*, *Mertensia maritima*, and *Stellaria humifusa*. Landward from the beaches, spits, and bars along the deltaic deposits, the same kinds of plants occur which grow along streams in the interior, e.g., with *Salix alaxensis* and other species of willow dominating along the edge of streams, and with *Empetrum*, *Ledum*, *Rhododendron*, and other woody species of plants. Meadows in the deltas are dominated by *Eriophorum*. Maritime vegetation gives way abruptly along sea cliffs to tussock tundra typical of the coastal plain.

AQUATIC VEGETATION

Streams in the region ordinarily have scoured bottoms and do not support a flora of higher plants. However, along the edge of some streams the yellow marsh marigold, *Caltha palustris*, grows in shallow water of quiet pools. Lakes support a variety of kinds of aquatic plants. In Old Crow Flats some lakes are filled with yellow pond lily, *Nuphar polysepala*. The pond lilies grow in a circular pattern some distance out from the edge of the pond in the deeper water. The margin of these ponds is occupied by species of *Carex*, *Triglochin maritima*, *Utricularia intermedia*, *Menyanthes trifoliata*, and *Ranunculus hyperboreus*. *Potamogeton alpinus* is attached and submersed in some ponds. Emergent vegetation in the lakes consists of *Utricularia*, *Menyanthes*, and species of *Carex*. Several species of

Carex, Scirpus caespitosus, and *Pinguicula vulgaris* grow in moist sites in the heath-taiga lands in Old Crow Flats.

A peculiar semiaquatic habitat occurs along the Babbage and Canoe Rivers and Timber Creek, where more or less permanent fields of ice spread out along basins in the braided stream course (Fig. 46). Willows and other woody species are embedded in the ice. As the ice melts the willows flower and grow leaves, but the growing season is much shortened and existence of this vegetative type appears tenuous.

Fig. 24. Patterned ground and poor Cretaceous exposures along the lower part of the Babbage River at approximately 58°57′ N; 139°21′ W. Moderately wet tussock tundra on patterned ground (foreground) and streambank and gravel bar vegetation (center and background).

COLLECTION LOCALITIES

During the summer of 1970 collections were made from 79 localities in northern Yukon (Fig. 47). Collections were made in the period between June 17 and August 15.

1. NE Mount Page. In British Mts., ca 4 miles northeast of Mount Page, in headwaters of unnamed river draining to Clarence Lagoon, ca 16 miles south of Beaufort Sea coast, at 69°24′ N, 149°50′ W, in alpine tundra on Kayak shale.
2. Malcolm River. In pass between Malcolm River and unnamed river draining to Clarence Lagoon, ca 14 miles south of Beaufort Sea coast, at 69°23′ N, 140°40′ W, at 2500 feet elevation, in alpine tundra on Kayak shale.
3. Mt. Conybeare, south flank. South flank of Mt. Conybeare, ca 8 miles south of Komakuk Beach, Beaufort Sea, at 68°28′ N, 140° 07′ W, at ca 1100 feet elevation, in rich tundra on limestone.
4. Mt. Conybeare, north flank. North flank of Mt. Conybeare, ca 7 miles south of Komakuk Beach, Beaufort Sea, at 68°29′ N, 140° 07′ W, at ca 1100 feet elevation, in rich tundra on limestone.
5. Loney Creek. Along Loney Creek, a tributary of Firth River, 6 miles southwest of confluence, at 69°20′ N, 139°50′ W, at ca 100 feet elevation, in arctic tundra, on Triassic limestone of the Shublik formation.
6. Lower Firth River. Gravel bar and meadow, along Firth River, ca 13 miles south of the Beaufort Sea, and 14 miles southwest of Herschel Island, at 69°22′ N, 139°32′ W, at 200 feet elevation, in willow dominated bar and *Dryas-Oxytropis* meadow.
7. Buckland Hills. North slope of Buckland Hills, on ridge adjacent to a small lake, ca ½ mile east of hill 722 and 20 miles south of Herschel Island, at 69°13′ N, 139°06′ W, at 700 feet elevation, in tundra on Neruopuk slate.
8. Ancient Beach. In Buckland Hills, on ancient, polygonally figured, gravelly beach, ca 2 miles north of Roland Creek and 23 miles south of Herschel Island, at 69°11′ N, 139°07′ W, at 900 feet elevation, in sparse tundra.
9. DC-3 Wreckage. Site of DC-3 wreckage, on divide between Spring River and Roland Creek, at 69°07′ N, 139°10′ W, at 1500 feet elevation, in sparse but rich alpine tundra, on Neruokpuk slates.
10. Three Pyramids section. British Mts., at 69° 02′ N, 139°43′ W, at 3000 feet elvation, on Kayak Shale in alpine tundra.
11. Crow-Trail. Ridge top, between Crow and Trail rivers, ca 24 miles southwest of Kay Point, at 69°00′ N, 138°46′ W, at 1000 feet elevation, in tundra on Neruokpuk slate.
12. Crow River. Gravel bar and braided stream channel, Crow River, north slope of Buckland Hills, at 69°05′ N, 138°40′ W, at ca 350 feet elevation, in willow community.
13. Coastal plain lake. Lake margin, ca 4 miles west-southwest of King Point, at 69°06′ N, 138°07′ W, at ca 200 feet elevation, in hummocky heath-tundra.
14. King Point. Sandy beach, at King Point, Beaufort Sea coast, at 69°07′ N, 137°58′ W, at near sea level, in maritime vegetation.
15. Firth River. Gravel bar, in Firth River at junction of Muskeg Creek, at 68°47′ N, 140° 28′ W, at ca 1400 feet elevation, with willows, dwarf birch, and white spruce.
16. Firth Lake. Lake shore and river gravel, along Firth River, British Mts., at 68°49′ N, 140°37′ W, at 1500 feet elevation, in *Betula-Salix* heath.
17. Firth-Muskeg divide. Ridge top between Firth River and Muskeg Creek, ca 12 miles east of Alaska border and 5 miles southeast of confluence of River and Creek, at 68°48′ N, 140°33′ W, at 3200 feet elevation, in rich tundra on Lisburne limestone.
18. Head Muskeg Creek. Ridge top, near head of Muskeg Creek, ca 13 miles south of confluence with Firth River, and 13 miles east of Alaska border, at 68°38′ N, 140°25′ W, at 2500 feet elevation, in poor tundra on siliceous Triassic Shublik formation.
19. Lisburne cliffs. Snow flush, on north side of small cliffs, in whitish Lisburne limestone ca 40 miles west of Sam Lake, near head of Timber Creek, at 68°32′ N, 140°08′ W, at 2800 feet elevation, in rich alpine tundra.
20. W Timber Creek. Ridge top, west of Timber Creek, ca 36 miles west of Sam Lake, at 68°26′ N, 140°05′ W, at 2800 feet elevation, in poor alpine tundra, on siliceous conglomerate.
21. Ridge 1800. Ridge top #1800, on Lisburne limestone, in northwestern portion of Old Crow Flats, at 68°22′ N, 140°40′ W, at 1800 feet elevation, in taiga.
22. Bear Creek. Along Bear Creek, a tributary of the Crow River, Buckland Mts., at 68°57′

Fig 25. View looking toward the southeast across the piedmont zone between the coastal plain and the hills along the Barn Mountains to the south. Stream in the foreground is at an elevation of approximately 50 feet. South across the coastal plain southwest of King Point from approximately 69°05′ N; 138°07′ W, near collecting locality 13. Wet tussock tundra on polygonal ground, dominated by *Eriophorum, Carex,* and *Salix* species.

N, 139°35′ W, at 2000 feet elevation, in alpine tundra.

23. Mt. Sedgwick. Northwest edge of Mt. Sedgwick, at 68°52′ N, 139°20′ W, at 2500 feet elevation, alpine tundra, in granite wash felsenmeer.
24. Trout Lake. North edge of Trout Lake, ca 30 miles north of Sam Lake, in Babbage River valley, at 68°50′ N, 138°45′ W, at 1000 feet elevation, in shrubby tundra.
25. Babbage River bend. Prominent bend in Babbage River, at 68°57′ N, 138°20′ W, at ca 400 feet elevation, in aretic tundra.
26. Babbage River lower. Gravel bar in prominent meander of Babbage River, on coastal plain, at 68°58′ N, 138°25′ W, at ca 400 feet elevation.
27. Deep Creek. Stream gravel, along Deep Creek, in shale slope, at 68°50′ N, 137°45′ W, at 490 feet elevation, with willows.
28. Deep Creek lower. Along Deep Creek, at 68°52′ N, 137°43′ W, at 400 feet elevation, in tundra over Cretaceous shale.
29. Blow River, Gravel bar, in prominent meander of Blow River, ca 12 miles south of Shingle Point, at 68°46′ N, 137°20′ W, at 300 feet elevation, in willow dominated community.
30. Blow River delta. Delta of Blow River, ca 2 miles east of Shingle Point, at 68°55′ N, 137°10′ W, at ca 2 feet elevation, in *Salix–Eriophorum–Alopecurus* community in open gravelly areas between rows of driftwood logs.
31. Upper Babbage River. Along Babbage River, ca 32 miles west-northwest of Sam Lake, at 68°38′ N, 139°45′ W, at 1200 feet elvation, in willow thicket and meadow, along black Kingak shale slope.
32. Babbage-Cottonwood. Hill top, between head of Babbage River and Cottonwood Creek, at 68°40′ N, 139°27′ W, at 1900 feet elevation, in tundra on Shublik sandstone outcrop.
33. Ridge 3261 north. South-facing slope, ca 3 miles north of #3261, ca 25 miles west-northwest of Sam Lake, at 68°32′ N, 139°24′ W, at 2000 feet elevation, on rocks stripes of siliceous formation.
34. Ridge 3261 NNE. Low cliff, on summit of ridge, ca 5 miles north-northeast of #3261, ca 21 miles west-northwest of Sam Lake, at

FIG. 26. Westward into Lisburne Limestone outcrops in the headwaters of Gravel Creek at approximately 68°43′ N, 139°43′ W. Peaks in the background have an elevation of approximately 3500 feet and a relief of 1000 to 1500 feet. Alpine tundra, on solifluction and talus slopes.

Fig. 27. Northwest from near collecting locality 49 at approximately 68°23′ N; 139°07′ W. Rocks in the foreground are limestone of the older Paleozoic Neruokpuk sequence exposed in the core of a small dome south of the main British Mountain trend. The darker slopes in the intermediate distance are on the Kayak Shale, with Lisburne Limestone forming the gentle cuesta and the hill in the intermediate distance. Rich alpine tundra.

68°32′ N, 139°18′ W, at 2500 feet elevation in rich tundra, on Permian Sadlerochit limestone.

35. S Babbage River. South fork of Babbage River, ca 18 miles northwest of Sam Lake, at 68°35′ N, 139°07′ W, at ca 2000 feet elevation, in tundra on Jurassic shales.
36. Babbage ice field. Lower ice field, near head of Babbage River, along bluff above south bank, at 68°40′ N, 139°07′ W, at 1000 feet elevation, in mixed heath-tussock tundra on Kingak shale.
37-38. Babbage River narrows. Narrows along Babbage River, ca 20 miles north-northwest of Sam Lake, at 68°43′ N, 139°02′ W, at ca 900 feet elevation, in tussock tundra along ridge crest, on Triassic rocks.
39. Canoe River. Head of Canoe River, ca 12 miles northwest of Sam Lake, at 68°34′ N, 138°58′ W, at ca 1700 feet elevation, in alpine tundra on Cretaceous shales.
40. Dog Creek upper. Along upper Dog Creek,

ca 9 miles north of Sam Lake, Barn Mts., at 68°32′ N, 138°42′ W, at ca 1800 feet elevation, tussock tundra and stream gravels.

41. Barn Mts. Reddish, slaty ridge top, in Barn Mts., ca 10 miles northeast of Sam Lake, at 68°33′ N, 138°18′ W, at ca 2500 feet elevation, in alpine tundra on Neruokpuk formation.
42. Fitton Creek. Along west fork of Fitton Creek, a tributary of Blow River, ca 22 miles east-northeast of Sam Lake, at 68°34′ N, 138°04′ W, at 1000 feet elevation, in snow flush along mossy slope, and in willow thicket.
43. NE Mt. Fitton. Ridge top, ca 4 miles northeast of Mt. Fitton, on summit between Fitton Creek and Blow River, at 68°30′ N, 137°52′ W, at 1900 feet elevation, in sparse alpine tundra, on Neruokpuk formation.
44. Ridge 3261 south. Ridge top, ca 2 miles south of #3261, ca 21 miles west-northwest of Sam Lake, at 68°28′ N, 139°25′ W, at 3200 feet elevation, in alpine tundra, in rock stripes of Ordovician-Silurian limestone.
45. Siliceous conglomerate. Outcrops of siliceous conglomerate, ca 23 miles west of Sam Lake, at 68°25′ N, 139°30′ W, at 2500 feet elevation, in poor alpine tundra.
46. Ridge 3261, 4 miles S. Ridge crest and saddle, ca 20 miles west of Sam Lake, at 28°27′ N, 139°22′ W, at 2800 feet elevation, in sparse alpine tundra, on slaty schist, in Neruokpuk formation.
47. Triassic-Lisburne contact. West Barn Mts., at Triassic-Lisburne contact, at 68°24′ N, 139°20′ W, at 2000 feet elevation, in alpine tundra.
48. Ridge 2651. Ridge top, about 14 miles west of Sam Lake, at 68°23′ N, 139°10′ W, at 2651 feet elevation, in alpine tundra on Ordovician-Silurian limestone.
49. Ridge 2651, 1 mile E. Ridge crest, ca 13 miles west of Sam Lake, ca 1 mile east #2651, at 68°23′ N, 139°08′ W, at 2500 feet elevation, in rock stripes, in patchy but rich tundra on Lisburne limestone.
50. Ridge 2651, 1 mile S. Ridge top, ca 14 miles west of Sam Lake, at 68°22′ N, 139°10′ W, at 2500 feet elevation, in tundra-taiga transition at contact zone between Kayak shale and Lisburne limestone.
51. Ridge 2651, 1.5 miles S. Ridge top, ca 14

FIG. 28. East across outcrops of massive Lisburne Limestone at locality 19 at approximately 2800 feet in the southern part of the British Mountains at 68°32′ N; 140°08′ W. Lakes in Old Crow Flat can be seen in the background to the southeast. Rich alpine tundra.

Fig. 29. Northwestward across Lisburne Limestone outcrops at Locality 19 on the ridge at the south edge of the British Mountains in the same areas as Figure 10. Alpine tundra, rich in species.

miles west of Sam Lake, ca 1.5 miles south of #2651, at 68°21′ N, 139°10′ W, at 2100 feet elevation in rock stripes and boulder patches with poor alpine tundra, on siliceous conglomerate and Kayak shale.

52. Small lake. Small lake in Old Crow Flats, ca 22 miles southwest of Sam Lake, at 68°16′ N, 139°22′ W, at ca 1000 feet elevation, emergent vegetation and surrounding *Betula-Rhododendron* heath and spruce woods.

53. Caribou trap. Historic caribou trap (late 19th century?), ca 11 miles west of Sam Lake, at 68°24′ N, 239°04′ W, at 2000 feet elevation, in parkland tundra.

54. Dog Creek north. Along Dog Creek, ca 6 miles northwest of Sam Lake, at 68°28′ N, 138°45′ W, at ca 2000 feet elevation, in a wet meadow with *Salix*, *Vaccinium*, *Arctostaphylos*, *Dryas*, *Carex*, and *Arnica*.
55. Kayak shale. Quartzitic member of Kayak shale, ca 6 miles northwest of Sam Lake, in Barn Mts., at 68°26′ N, 138°48′ W, at 2000 feet elevation, in poor alpine tundra.
56. Black Fox Creek. Gravel bar, in Black Fox Creek, ca 5 miles west of Sam Lake, at 68°24′ N, 138°49′ W. at 1400 feet elevation, with willows and tussock tundra.
57. Sedge meadow. Summit of ridge, in Lisburne limestone, south end of Barn Mts., ca 3 miles northwest of Sam Lake, at 68°26′

FIG. 30. Kayak Shale and overlying Lisburne Limestone along the west bank of the headwaters of Canoe River above the elf icefield at approximately 68°37′ N; 138°43′ W at an elevation of approximately 900 feet. Inhospitable barrens, heath, and patchy tundra on solifluction slope and talus.

Fig. 31. Broad tundra-covered slope blanketing strongly folded Neruokpuk beds near collecting locality 46 at 68°27′ N; 139°22′ W at approximately 2700 feet. Small platy angular debris is of siliceous schistose beds in the Neruokpuk Formation. Sparse alpine tundra, with patches of *Dryas* dominating.

N, 138°40′ W, at 2500 feet elevation, in sedge meadow, alpine tundra.

58. Lisburne limestone. Rocky ridge top, ca 4 miles northwest of Sam Lake, at 68°27′ N, 138°40′ W, at 2578 feet elevation, in alpine tundra, on Lisburne limestone.
59. Dog Creek. Gravel bar, along Dog Creek, ca 4 miles northwest of Sam Lake, at 68°26′ N, 138°45′ W, at ca 1400 feet elevation, in willow community.
60. Spruce woods. Grove of spruce woods, on south-facing slope, ca 3 miles northwest of Sam Lake, at 68°26′ N, 138°40′ W, at 1550 feet elevation, on Lisburne limestone.
61. NW Sam Lake. Wet, polygonal tundra, ca 1 mile northwest of Sam Lake, at 68°25′ N, 138°38′ W, at ca 1600 feet elevation.
62. Sam Lake. Around margin of north side of Sam Lake, at 68°25′ N, 138°37′ W, at 1500 feet elevation in *Salix-Carex* heath.

63. Sam Lake west. Around west margin of Sam Lake, at 68°25′ N, 138°38′ W, at 1500 feet elevation, in *Salix-Carex* heath.
64. Dog Creek head. Along head of Dog Creek, ca 6 miles north of Sam Lake, at 68°28′ N, 138°35′ W, at 2200 feet elevation, in riparian vegetation, heath, snow flush, and alpine tundra, on sandstone.
65. Sandstone. Rock stripes, in Cretaceous sandstone, ca 4 miles northeast of Sam Lake, Barn Mt., at 68°27′ N, 138°31′ W, at ca ca 2000 feet elevation, in poor alpine tundra.
66. W Barn Mts. Triassic-Lisburne contact, west Barn Mts., at 68°24′ N, 138°20′ W, at 2000 feet elevation, in tundra.
67. Timber Creek. Gravel bar, along Timber

FIG. 32. Northwestward from Mt. Fitton to Twin Peaks. The rocks on Mt. Fitton in the foreground are slightly weathered siliceous granitic rocks. Slopes of Twin Peaks in the background are carved in large part in strongly folded slates of the Nernokpuk sequence overlain by coarse conglomerates of the late Paleozoic sequence. The Twin Peaks rise to an elevation of approximately 2600 feet. Rocks of Mt. Fitton in the foreground are at an elevation of approximately 1500 feet. Alpine tundra, with boulder patches, solifluction slopes, and sparsely covered slopes and rock outcrops.

Fig. 33. Southwest from Mt. Fitton into the headwaters of Boulder Creek and the main high ridges of the Barn Mountains. Rocks in the foreground are the Mt. Fitton granodiorite, and those in the background are strongly folded Neruokpuk Formation. The high peak along the skyline in the distance is at approximately 3500 feet. Mt. Fitton exposures in the foreground are at approximately 1500 feet. Alpine tundra.

Creek, a tribntary of Old Crow River, ca 33 miles southwest of Sam Lake, at 68°11′ N, 139°47′ W, at ca 900 feet elevation, in white spruce-white birch woods and willow dominated bar.

68. Lower Black Fox. Gravel bar, along Black Fox Creek, at 68°07′ N, 139°28′ W, at ca 900 feet elevation, in spruce-willow-poplar taiga.
69. Rose Lake. Gravelly north shore of Rose Lake, Old Crow Flats, at 68°06′ N, 139°23′ W, at 900 feet elevation.
70. Taiga pond. Pond and adjacent taiga-heathland, ca 22 miles south-southwest of Sam Lake, at 68°08′ N, 139°05′ W, at ca 1000 feet elevation.
71. Black Fox Creek lower. Along Black Fox Creek, ca 13 miles southwest of Sam Lake, at 68°15′ N, 138°50′ W, at 1100 feet elevation on gravel bar, with cottonwood and willows.
72. Unnamed lake. Small unnamed lake, in Old Crow Flats, ca 16 miles south of Sam Lake, at 68°12′ N, 138°49′ W, at ca 1200 feet elevation, on humus beach and lake basin margin, with aquatic plants and heath.
73. Ridge 1578. Small hill, #1578, in northeastern portion of Old Crow Flats, at 68°12′ N, 138°45′ W, at 1578 feet elevation, in spruce taiga.
74. Neruokpuk limestone. West side of Blow River Valley, at 68°17′ N, 137°50′ W, at 2200 feet elevation, in alpine tundra, on Neruokpuk limestone.
75. Cretaceous mudstone. Head of Blow River, along a creek margin ca 27 miles southeast of Sam Lake, at 68°17′ N, 137°17′ W, at 1500 feet elevation, in tundra.
76. Old Crow. Along gravel bar and first terrace above Porcupine River at Old Crow, at 67°35′ N, 139°50′ W, at ca 900 feet elevation, in white spruce woods and riparian vegetation, on alluvium.
77. Old Crow landing strip. Landing strip on river bar, ca 8 miles east of Old Crow, at 67°34′ N, 139°32 W, at 900 feet elevation, in willow community.
78. Porcupine River bluff. Bluff west of bend in Porcupine River, ca 31 miles east of Old

Crow, at 67°36′ N, 138°38′ W, at 100 feet elevation, in spruce woods.

79. Conglomerate hill. On siliceous conglomerate hill, ca 39 miles east of Old Crow, at 67°32′ N, 138°23′ W, at 2000 feet elevation, in heathlands and tundra.

CHECKLIST OF VASCULAR PLANTS

The following list of plants collected during 1970 is arranged in phylogenetic sequence to the subdivision level and is alphabetically arranged thereafter. Collectors names are abbreviated with WR for S. L. Welsh and J. K. Rigby, and Rigby for J. K. Rigby. All specimens are deposited at BRY. A summary of taxa collected is presented at the end of the checklist (Fig. 48). Distribution records were checked against maps published by Hulten (1968) and Porsild (1964). Identifications were made by comparison of specimens collected with keys provided by Hulten and Porsild and with an unpublished manuscript of "Anderson's Flora of Alaska and adjacent Canada" (Welsh, 1971).

LYCOPSIDA

Lycopodiaceae Clubmoss Family

Lycopodium selago L.

Locality #41, WR 10291, 8 July; #43, WR 10720, 15 July. Alpine tundra, ridgetops, on slate.

Selaginellaceae Spikemoss Family

Selaginella sibirica (Milde) Hieron

Locality #9, WR 10139a, 1 July; #41, WR 10297, 8 July. Alpine tundra, ridgetops, on slate.

SPHENOPSIDA

Equisetaceae Horsetail Family

Equisetum arvense L.

Locality #15, WR 70578a, 12 July; #16, Rigby 34, 23 June; #59, WR 10051, 30 June; #77, Rigby 11, 18 June. Gravel bars, and forming vast green patches along moist upland sites.

FIG. 34. South across the south flank of the British Mountains into Old Crow Flats from approximately 68°24′ N; 139°16′ W near locality 45. Rocks in the foreground are siliceous cherty conglomerate underlying the Kayak Shale, the soft unit which forms the broad valley in the intermediate distance. The light colored ridges beyond the valley and along the margin of Old Crow Flats are in Lisburne Limestone. Old Crow Flats to the south is an area where broad marshes and lakes are extensively developed on Tertiary and Quaternary fill. Alpine tundra dominated by *Betula glandulosa, Dryas, Loiseleuria,* and *Empetrum.*

Fig. 35. Siliceous iron-rich siltstones and shale in the Permian Sadlerochit Formation as seen from the head of Muskeg Creek at 68°31′ N; 140°32′ W near collecting locality 18, looking toward the north to the main part of the British Mountains. The broad open flats in the background are at an elevation of 2000 feet. Rocks in the foreground are at an elevation of 2500-2600 feet. Sparse alpine tundra, dominated by *Dryas, Betula,* and *Empetrum.*

Equisetum scirpoides Michx.

Locality #26, WR 10699, 15 July. Gravel bar.

PTEROPSIDA-FILICINEAE

Polypodiaceae Fern Family

Cystopteris fragilis (L.) Bernh.

Locality #17, WR 10557a, 12 July; #19, WR 10550, 12 July; #32, WR 10209, 3 July. On low cliffs and talus slopes, in alpine tundra, on sandstone and limestone. This is the first report of *C. fragilis* for northern Yukon.

Dryopteris fragrans (L). Schott.

Locality #33, WR 10389, 9 July. Siliceous conglomerate, in alpine tundra. This is the first record of *D. fragrans* for northern Yukon.

PTEROPSIDA-GYMNOSPERMIAE

Pinaceae Pine Family

Picea glauca (Moench) Voss

Locality #16, Rigby 25, 23 June; #60, WR 10046, 30 June; #67, WR 10096, 1 July; #76, WR 10432, 10 July. On terraces, gravel bars, lake shores, and mountain slopes, in taiga and boreal forest. A dominant species.

Picea mariana (Mill.) Britt., Sterns., Pogg.

Locality #50, WR 10509, 11 July. Tundra-taiga transition, an Kayak shale. This specimen has only a few hairs along the leaf base and lacks cones. It is tentatively assigned to *P. mariana*, but might represent a hybrid with *P. glauca*.

PTEROPSIDA-ANGIOSPERMIAE-DICOLYLEDONEAE

Betulaceae Birch Family

Alnus crispa (Ait.) Pursh

var. *crispa*

Locality #30, WR 10323, 8 July, #36, WR 10194, 3 July; #72, 10654, 13 July. Stream bank and heathland component, widespread.

Betula glandulifera (Reg.) Butler

Locality #67, WR 10097, 1 July; #79, Rigby 130b, 26 July. These are shrubs with characteristics intermediate between *B. glandulosa* and *B. papyrifera*. They grow along river banks and bluffs in Old Crow Flat.

Betula glandulosa Michx.

var. *glandulosa*

Locality #8, WR 10147, 1 July; #16, Rigby 27, 40, 23 June; #24, WR 10126, 1 July; #52, WR 10479, 11 July; #65, WR 10301, 8 July; #73, Rigby 54, 24 June. Dwarf bireh is abundant in most phases of alpine and arctic tundra and heathlands. In favorable locations it is erect, reaching a height of 2 to 4 feet. In less favorable sites, it is a prostrate spreading shrub.

Betula papyrifera Marsh

var. *neoalaskana* (Sarg.) Raup

Locality #67, WR 10095, 1 July; #79, Rigby 130, 134, 26 July. White birch is a component of riparian woods and occurs on bluffs along stream channels in the lower reaches of Old Crow Flat.

FIG. 36. Southeastward across white spruce woods toward Sam Lake along the north side of Old Crow Flats. The woods are at approximately 68°25′ N; 138°40′ W. Collecting locality 60 is in the point of woods in the immediate right center, at the edge of the tundra, at an elevation of approximately 1550 feet. Mixed heathland and tussock tundra are in the foreground.

Fig. 37. East up Skidoo Creek at 68°51′ N; 140°13′ W, east of collecting locality 15. All the rocks immediately visible in the foreground are in the Lisburne Limestone. The valley bottom in the foreground is at an elevation of approximately 1500 feet, with peaks along the skyline at about 2000 feet. White spruce woods, near northern limit of trees along Firth River valley.

Boraginaceae Borage Family

Eretrichium nanum (Vill.) Schrad.

var. *aretioides* (Cham.) Herder

Locality #1, WR 10262, 5 July; #2, WR 10247, 5 July; #48, WR 10518, 11 July. Alpine tundra and barrens.

var. *chamissonis* (DC.) Herder

Locality #3, WR 10176, 1 July; #4, WR 10226, 4 July; #23, Rigby 96, 25 June. Alpine tundra and barrens.

Mertensia maritima (L.) S. F. Gray

Locality #14, WR 10033, 30 June; do, WR 10686, 15 July. Gravelly beaches and spits along the sea coast.

Mertensia paniculata (Ait.) G. Don

ssp. *paniculata*

Locality #5, WR 10603, 13 July; #31, WR 10405, 9 July; #54, WR 10276, 6 July; #59, 10062, 30 June. Gravel bars, meadows, and alpine and arctic tundra.

Myosotis sylvatica Hoffm.

Locality #3, WR 10178, 1 July; #5, WR 10610, 13 July; #25, WR 10624, 13 July; #27, Rigby 141, 28 July; #40, WR 10506, 11 July; #59, WR 10065, 30 June. Streams gravels, tussock tundra, alpine tundra, and barrens.

Caryophyllaceae Pink Family

Arenaria arctica Stev

Locality #1, WR 10261, 5 July; #3 WR 10180, 1 July; #4, WR 10218, 3 July; #8, WR 10152, 1 July; #9, WR 10133, 1 July; #16, Rigby 71, 24 June; #17, WR 10558, 12 July; #32, WR 10211, 3 July; #42, WR 10293a, 8 July; #43, WR 10714, 15 July; #59, WR 10059, 30 June. Ridge tops, alpine slopes, tussock tundra, and stream gravels, common to abundant.

Arenaria laricifolia L.

var. *hultenii* Welsh

Locality #46, WR 10378, 9 July; #55, WR 10068a, 30 June; #79, Rigby 133, 26 July. Siliceous outcrops and on limestone, in alpine tundra.

var. *laricifolia*

Locality #29, WR 10355, 9 July; #45, WR 10539, 12 July; #50, WR 10524, 11 July; #51, WR 10514, 11 July; #51, WR 10362, 9 July; #66, Rigby 107, 22 July. Siliceous conglomerates

FIG. 38. Gravel bar at Firth Rock and collecting locality 15 in the foreground. Most of the plants were collected to the right beyond the picture on the frequently covered crest of the gravel bar. White spruce, willow, alder, and dwarf birch dominate the talus slopes.

and quartzites and less commonly on limestones, in alpine tundra.

Arenaria macrocarpa Pursh

Locality #29, WR 10744, 15 July (from a rounded, hemispheric clump 3 feet in diameter); #40, WR 10510, 11 July; #41, WR 10293, 8 July; #43, WR 10716, 15 July. Stream gravels and slaty ridge tops.

Arenaria peploides L.

var. *peploides*

Locality #14, WR 10032, 30 June; do, WR 10681, 15 July. Sea beach and spit gravels.

Arenaria physodes Fisch.

Locality #67, WR 10110, 1 July. Stream gravels and bars.

Arenaria rossii R. Br.

var. *elegans* (C. & S.) Welsh

Locality #34, WR 10397, 9 July; #46, WR 10369, 9 July. Alpine tundra, on limestone.

Arenaria rubella (Wahl.) Smith

fma. *exilis* (Fern.) Polunin

Locality #9, WR 10141, 1 July. Alpine tundra on Neruokpuk formation.

Fig. 39. Northwest along Pleistocene beach ridges. The prominent light scar in left center is a graveled beach at approximately 68°12′ N; 139°02′ W at the eastern shore of a broad lake which occupied Old Crow Flats. Black Fox Creek in the middle distance is lined by spruce. British Mountains rise along the skyline beyond Old Crow Flats. Parkland tundra (taiga) and heathland.

var. *rubella*

Locality #11, WR 10187, 1 July; ±59, WR 10050, 30 June; do, WR 10465, 10 July. Gravel bars, and alpine tundra on Neruokpuk formation.

Arenaria sajanensis Willd.

Locality #64, WR 10642, 14 July. Shrubby, alpine tundra, in a snow flush.

Cerastium beeringianum Cham. & Schlecht.

var. *beeringianum*

Locality #12, WR 10453, 10 July; #44, WR 10367, 9 July; #59, WR 10053. Alpine tundra on limestone and on gravel bars and braided stream channels.

Cerastium maximum L.

Locality #76, WR 10434, 10 July. River terrace alluvium in white spruce woods.

Lychnis apetala L.

Locality #44, WR 10365, 9 July; #49, WR 10356, 9 July. Alpine tundra, on limestone.

Lychnis furcata (Raf.) Fern

Locality #34, WR 10391, 9 July. Alpine tundra, on limestone.

Lychnis triflora R. Br.

var. *dawsonii* Robins.

Locality #67, WR 10113, 1 July. Gravel bar, in lower Old Crow Flats.

Silene acaulis L.

var. *exscapa* (All.) DC.

Locality ±2, WR 10257, 5 July; #4 WR 10217, 3 July; do, WR 10241, 4 July; #5, WR 10615, 13 July (peduncles filiform, to 1.5 cm long); #6, WR 10169, 1 July; #37, WR 10092, 30 June. Alpine and arctic tundra, on ridge tops, slopes, and gravel bars, common to abundant.

Silene repens Pers.

Locality #31, WR 10401, 9 July; ±66, Rigby 109, 22 July. Gravel bars and tussock tundra.

Stellaria humifusa Rottb.

Locality #14, WR 10682, 15 July. Sea beach and spit gravels.

Stellaria longifolia Muhl.

Locality ±70, WR 10662, 15 July. Pond margin, in taiga.

Stellaria longipes Goldie

var. *altocaulis* (Hulten) C.L. Hitchc.

Locality ±12, WR 10452, 10 July. Gravel bars, in braided arctic stream channel.

var. *edwardsii* (R. Br.) Gray

Locality #56, WR 10590, 12 July. Gravel bar, in stream channel.

var. *laeta* (Richards.) Wats.

Locality ±14, WR 10674, 15 July; #50, WR 10530, 11 July; #59, WR 10060, 30 June. Sea beach and spit, alpine tundra, and gravel bars.

var. *longipes*

Locality #5, WR 10612, 13 July; ±29, WR 10739, 15 July; #67, Rigby 58, 24 June; do, WR 10104, 1 July. Gravel bars.

Compositae Composite Family

Achillea millefolium L.

ssp. *boreale* (Bong.) Breitung

Locality ±26, WR 10706, 15 July; #29, WR 10736, 15 July; #68, Rigby 159, 20 July; #76, WR 10420, 10 July; ±78, Rigby 127, 26 July. River bluffs, terraces, and gravel bars.

Antennaria alpina (L.) Gaertn.

var. *compacta* (Malte) Welsh

Locality #11, WR 10192, 1 July; ±18, WR 10554, 12 July. Alpine tundra, in siliceous sandstones and slaty shales.

Antennaria monocephala DC.

Locality ±8, WR 10151, 1 July; #9, WR 10146a, 1 July; #40, WR 10641, 14 July. Alpine tundra and heathlands.

Arnica alpina (L.) Olin

var. *angustifolia* (Vahl) Fern.

Locality #1, WR 10263a, 5 July; ±4, WR 10232, 4 July; ±5, WR 10601, 13 July; ±50, WR 10532, 11 July. Alpine and arctic tundra.

ssp. *attenuata* (Greene) Maguire

var. *attenuata*

Locality #12, WR 10447, 10 July; ±33, WR 10379, 9 July; #25, WR 10621, 13 July; ±54, WR 10273, 6 July. Stream banks, meadows, and bars.

Arnica lousiana Farr.

var. *frigida* (C.A. Mey.) Welsh

Locality #1, WR 10263, 5 July; ±15, WR 10563, 12 July; #32, WR 10205, 3 July. Alpine tundra.

Artemisia alaskana Rydb.

Locality ±26, WR 10700, 15 July. Gravel bar.

Artemisia glomerata Ledeb.

Locality #9, WR 10138, 1 July; ±10, Rigby 75, 91, 25 June. Alpine tundra, on Neruokpuk formation and Kayak shale.

Artemisia norvegica Fries

var. *comata* (Rydb.) Welsh

Locality #12, WR 10446, 10 July; #43, WR 10725, 15 July; #64, WR 10639, 14 July. Gravel bars, and alpine tundra.

Artemisia tilesii Ledeb.

var. *unalaschcensis* Besser

Locality #14, WR 10675, 15 July; #26, WR 10701, 15 July; #29, WR 10739, 15 July; #59, WR 10468, 10 July; #67, WR 10106, 1 July; #68, Rigby 157, 20 July; #78, Rigby 126, 26 July. Gravelly sea beaches and spits, and on gravel bars, terraces, and river bluffs.

Aster sibiricus L.

Locality #68, Rigby 156, 20 July; #76, WR 10426, 10 July; #78, Rigby 125, 26 July. River bars, terraces, and bluffs, in Old Crow Flats.

Crepis nana Richards.

Locality #12, WR 10444, 10 July; #15, WR 10570a, 12 July; #16, Rigby 69, 24 June; #19, WR 10552, 12 July; #25, WR 10622a, 13 July; #49, WR 10352, 9 July; #59, WR 10462, 10 July; #67, WR 10105, 1 July. Bars and stream banks and on talus and ridge tops in tundra.

Erigeron acris L.

var. *kamtschaticus* (DC.) Herder

Locality #68, Rigby 154, 20 July; #71, WR 10496, 11 July. Gravel bars, in Old Crow Flats.

Erigeron humilus Grah.

Locality #50, WR 10536, 11 July; #51, WR 10515a, 11 July. Kayak shale, in alpine tundra.

Erigeron lonchophyllus Hook.

Locality #22, WR 0713, 15 July. Tussock tundra.

Erigeron purpuratus Greene

Locality #59, WR 10459, 10 July; #71, WR 10500, 1 July. Gravel bars, along streams in Old Crow Flats.

Erigeron yukonensis Rydb.

Locality #34, WR 10390, 9 July; #50, WR 10527, 11 July; #51, WR 10508, 11 July; #66, Rigby 106, 22 July. On Kayak shale, and contact between Shublik and Lisburne limestones in alpine tundra. The specimens do not fit the published description of *E. yukonensis* exactly. In fact, they closely resemble *Aster alpinus* var. *vierhappeii*, but have bright pink purple rays.

Fig. 40. Southwestward across lakes along the west bank of Old Crow River, toward Shaffer Creek drainage. Lakes at the right are at 67°55′N; 139°44′ W. The relatively well-drained bank of Old Crow River is toward the east (left). Elevation is approximately 950 feet. Riparian woods of *Picia glauca*, *Salix*, and *Populus*, and heathlands of *Betula glandulosa* and *Salix*.

FIG. 41. Parkland tundra near the uppermost limit of trees along Timber Creek at approximately 68°26′ N; 139°45′ W. Abandoned meanders show along the gravel margin. Exposures of Lisburne Limestone show as the light colored barren area in the upper left. *Salix* and *Picea glauca* fringed stream and meander.

Matricaria matricarioides (Les.) Porter

Locality #76, WR 10435, 10 July. Weed of disturbed sites, at Old Crow.

Petasites frigidus (L.) Fries

var. *frigidus*

Locality #24, WR 10124a, 1 July; #42, WR 10332, 8 July; #60, WR 10036, 30 June. Meadows, willow thickets, and heathlands.

Saussurea angustifolia (Willd.) DC

var. *angustifolia*

Locality #33, WR 10386, 9 July; #51, WR, 10515, 11 July; #56, WR 10591, 12 July. Siliceous conglomerates in alpine tundra, heathlands, and on gravel bars.

Senecio atropurpureus (Ledeb.) Fedtsch.

var. *ulmeri* (Steffen) Porsild

Locality #4, WR 10239, 4 July; #7, WR 10159, 1 July; #16, Rigby 68, 24 June; #34, WR 10204, 3 July; #40, WR 10644, 14 July; #57, WR 10078, 30 June; #60, WR 10044, 30 June. A dominant species in tundra generally. Both ligulate and nonligulate phases are represented.

Senecio congestus (R. Br.) DC.

Locality #14, WR 10673, 15 July; #62, WR 10549a, 13 July; #72, WR 10649, 14 July. Gravelly seashores and spits, and lakes shores.

Senecio fuscatus (Jord. & Fourr.) Hayek

Locality #9, WR 10142, 1 July; #43, WR 10721, 15 July. Alpine sparse tundra, on Neruokpuk formation.

Senecio lugens Hook

Locality #5, WR 10605, 13 July; #25, WR 10622, 13 July; #27, Rigby 143, 28 July; #29, WR 10737, 15 July; #50, WR 10529, 11 July; #54, WR 10284, 6 July; #59, WR 10473, 10 July; #67, WR 10108, 1 July; #71, WR 10495, 11 July. Gravel bars and meadows.

Senecio resedifolius Less.

Locality #1, WR 10264, 5 July; #9, WR 10143, 1 July; #44, WR 10364, 9 July; #48, WR 10348, 9 July; #74, Rigby 137, 26 July. Alpine tundra, on limestone, slates, and shales.

Senecio yukonensis Porsild

Locality #40, WR 10644a, 14 July. Shrubby tundra.

Solidago multiradiata Ait.

Locality #5, WR 10606, 13 July; #15, WR 10570, 12 July. Gravel bars and stream banks.

Tanacetum bipinnatum (L.) Schulz-bip
ssp. *huronense* (Nutt.) Welsh
Locality #76, WR 10424, 10 July; #78, Rigby 123, 26 July. Gravel bars and river terraces, in Old Crow Flats.

Taraxacum ceratophorum (Ledeb.) DC.
Locality #59, WR 10458, 10 July; #67, WR 10111, 1 July. Gravel bars and river terraces,

Taraxacum lyratum (Ledeb.) DC.
Locality #2, WR 10245, 5 July; #64, WR 10640, 14 July; #58, WR 10476, 11 July. Alpine tundra, on Lisburne limestone, Kayak shale, and Jurassic shales.

Crassulaceae Stonecrop Family

Sedum roseum (L.) Scop.
var. *integrifolium* (Raf.) Berger
Locality #4, WR 10215, 3 July; #10, Rigby 81, 25 June. Alpine tundra.

Cruciferae Mustard Family

Alyssum americanum Greene
Locality #48, WR 10344, 9 July; #50, WR 10526a, 11 July; #51, 10513, 11 July. Alpine tundra, on limestone outcrops. These collections represent a northward extension of the range of the species in the Yukon.

Arabis hirsuta Lange
var. *pycnocarpa* (Hopkins) Rollins
Locality #67, WR 10101, 1 July; do, Rigby 60, 24 June. River bar. These collections represent the northernmost known limits of this entity in the Yukon.

Barbarea orthoceras Ledeb.
Locality #67, WR 10102, 1 July; #69, Rigby 150, 20 July. Lake shores and gravel bars, in Old Crow Flats.

Braya humilus (C.A. Mey.) Robins
ssp. *arctica* (Bucher.) Rollins
Locality #15, WR 10565, 12 July. Gravel bar, in Firth River. This specimen is apparently the first record of *B. humilus* for northern Yukon.

Braya purpurascens (R.Br.) Bunge
Locality #50, WR 10345, 9 July. Alpine tundra, on limestone. This specimen is apparently the first record of *B. purpurascens* for the Yukon.

Cardamine bellidifolia L.
Locality #42, WR 10322a, 8 July. Snow flush and willow thicket.

Cardamine digitata Richards.
Locality #11, WR 10191, 1 July; #13, WR 10692, 15 July; #14, WR 10687, 15 July; #34, WR 10202, 3 July; #57, WR 10076, 30 June; #64, WR 10641a, 14 July. Tussock and shrubby tundra.

Cardamine microphylla Adams
Locality #1, WR 10260, 5 July; #2, WR 10249, 5 July. Alpine tundra, on Kayak shale. This is apparently a new record for the Yukon.

Cardamine pratensis L.
Locality #62, WR 10223, 4 July. Lake shore.

Cochearia officinalis L.
var. *arctica* (Schleeht.) Gel.
Locality #14, WR 10688, 15 July. Sea beaches and spits.

Descurainia sophioides (Fisch.) Schulz
Locality #14, WR 10670, 15 July; #76, WR 10425, 10 July. Gravel bars and terraces along rivers, and near an abandoned dwelling along the sea coast.

Draba alpina L.
Locality #16, Rigby 72, 24 June. Gravelly river bank.

Draba caesia Adams
Locality #3, WR 10182, 1 July; #4, WR 10216, 3 July; #6, WR 10166a, 1 July; #9, WR 10135, 1 July; #10, Rigby 79, 25 June; #48, WR 10341, 9 July. Alpine tundra, in limestone, shales, and slates, and on gravel bars. Common.

Draba cinerea Adams
Locality #5, WR 10618a, 13 July; #21, Rigby 115, 25 July; #34, WR 10395, 9 July; #73, Rigby 49, 24 June. Alpine tundra, on limestone and sandstone.

Draba glabella Pursh
Locality #10, Rigby 77, 25 June; #14, WR 10685, 15 July; #31, WR 10408, 9 July; #59, WR 10061, 30 June; #64, WR 10643, 14 July. Gravel bars along streams, and sea beaches and spits.

Draba lactea Adams
Locality #2, WR 0254, 5 July; #4, WR 10238, 4 July; #17, WR 10562, 12 July; #19, WR 10544, 12 July; #32, WR 10210, 3 July; #44, WR 10363, 9 July; #64, WR 10636, 14 July. Sandstone, limestone, shales, and slates, in alpine tundra, The specimens cited herein are evidently the first records of this species for northern Yukon.

Draba longipes Raup

Locality #50, WR 10538, 11 July. In tundra-taiga transition at contact between Kayak shale and Lisburne limestone.

Erysimum chieranthoides L.

Locality #68, Rigby 158, 20 July; #78, Rigby 129, 26 July. Gravel bars and stream terraces, in Old Crow Flats.

Erysimum inconspicuum (Wats.) MacM.

Locality #25, WR 10623, 13 July; #26, WR 10698, 15 July. Gravel bars, along arctic streams. These specimens are apparently the first record of this species for northern Yukon.

Erysimum pallasii (Pursh) Fern.

Locality #10, Rigby 74, 25 June; #12, WR 10443, 10 June; #31, WR 10402, 9 July; #50, WR 10353, 9 July; #59, WR 10049, 30 June; do, WR 10464, 10 July. Gravel bars, and alpine tundra.

Lesquerella arctica (Wormskj.) Wats.

Locality #16, Rigby 64, 24 June; #37, WR 10081, 30 June. Alpine tundra, on Triassic rocks, and on gravelly river bank.

Parrya nudicaulis (L.) Reg.

Locality #3, WR 10171, 1 July; #4, WR 10233, 4 July; #10, Rigby 80, 25 June; #13, WR 10693a, 15 July; #16, Rigby 21, 30, 35, 23 June; do, Rigby 66, 24 June; #37, WR 10090a, 30 June. A dominant species in tussock and alpine tundra. Common.

Rorippa islandica (Oed.) Borbas

var. *hispida* (Desv.) Butters & Abbe

Locality #70, WR 10663, 15 July; #72, WR 10655, 14 July; #76, WR 10430, 10 July. Lake shores, gravel bars, and river terraces.

Smelowskia borealis (Greene) Drury & Rollins

Locality #17, WR 10556a, 12 July. Talus slope, on limestone. This specimen represents a range extension eastward and northward from previous records.

Smelowskia calycina (Steph.) C. A. Mey.

var. *media* Drury & Rollins

Locality #2, WR 10243, 5 July; #4, WR 10213, 3 July; #6, WR 10167, 1 July; #7, WR 10154, 1 July; #8, WR 10149, 1 July; #9, WR 10140, 1 July; #10, Rigby 90, 25 June; #16, Rigby 62, 24 June; #24, WR 10125, 1July; #41,

FIG. 42. Black Fox Creek at the margin of Old Crow Flat looking toward the southwest from approximately 68°15′ N; 138°76′ W. *Picea glauca* woods, margined with *Salix*, *Betula papyrifera*, and *Populus*.

WR 10292, 8 July; #43, WR 10722, 15 July; #46, WR 10582a, 12 July. A dominant on semibarren ridgetops and abandoned beaches, and less commonly in stream gravels. This is evidently the first report of *S. calycina* from the Yukon.

Elaeagnaceae Oleaster Family

Shepherdia canadensis (L.) Nutt.

Locality #59, WR 10052, 30 June; #68, Rigby 100, 20 July. Gravel bars, along stream courses.

Empetraceae Crowberry Family

Empetrum nigrum L.

var. *hermaphroditicum* (Lge.) Sor.

Locality #36, WR 10199, 3 July; #65, WR 10300, 8 July. A dominant in tussock tundra and heathlands. This is evidently the first report of *E. nigrum* for northern Yukon.

Ericaceae Heath Family

Andromeda polifolia L.

Locality #60, WR 10045, 30 June; #62, WR 10031a, 30 June. Lake shores, heathlands, and taiga.

Arctostaphylos alpina (L.) Spreng

Locality #5, WR 10618, 13 July; #7, WR 10161, 1 July; #15, WR 10564, 12 July; #25, WR 10628a, 13 July; #73, Rigby 47, 24 June. A dominant species in tussock tundra and on ridges and slopes in alpine tundra, and along stream courses.

Cassiope tetragona (L.) D. Don

var. *tetragona*

Locality #1, WR 10269, 5 July; #10, Rigby 82, 25 June; #16, Rigby 24, 23 June; #42, WR 10331, 8 July; #55, WR 10070, 30 June; #60, WR 10041, 30 June; #73, Rigby 53, 24 June. Alpine tundra, heathland, and taiga. A dominant common species.

Ledum decumbens (Ait.) Lodd.

Locality #30, WR 10319, 8 July; #55, WR 10071, 30 June; #60, WR 10044b, 30 June; #73, Rigby 57, 24 June. Woodlands, lake shores, stream banks, and deltas.

Loiseleuria procumbens (L.) Desv.

Locality #39, WR 10129, 1 July; #47, WR 10359, 9 July; #73, Rigby 45, 24 June. Poor tundra on siliceous conglomerates, sandstone, and shale.

Rhododendron lapponicum (L.) Wahl

Locality #5, WR 10604, 13 July; #6, WR 10166, 1 July; #16, Rigby 15, 21, 29, 23 June; #37, WR 10083, 30 June; #60, WR 10042, 30 June; #73, Rigby 52, 24 June. Tundra, heathland, and taiga, widespread and common.

Vaccinium uliginosum L.

Locality #7, WR 10160, 1 July; #36, WR 10201, 3 July; #62, WR 10024, 30 June. A dominant species in tussock tundra, heathlands, and taiga.

Vaccinium vitis-idaea L.

Locality #63, WR 10306, 8 July. Shrubby tundra and taiga.

Gentianaceae Gentian Family

Gentianella propinqua (Richards.) Gillette

Locality #26, WR 10704, 15 July. Gravel bar. Evidently rare.

Haloragaceae Watermilfoil Family

Hippurus vulgaris L.

Locality #62, WR 10313, 8 July. Emergent in lake margin.

Leguminosae Legume Family

Astragalus alpinus L.

Locality #12, WR 10449a, 10 July; #16, Rigby 14, 23 June; #29, WR 10732a, 15 July; #36, WR 10203, 3 July; #59, WR 10461, 10 July; do, WR 10047, 30 June; #67, Rigby 61, 24 June. Tussock tundra and gravel bars. Widespread and locally common.

Astragalus australis (L.) Lam.

Locality #3, WR 10175, 1 July; #12, WR 10440, 10 July; #15, WR 10580, 12 July; #32, WR 10207, 3 July; #37, WR 10080, 30 June. Ridge tops, on limestone or sandstone, and on river gravels on the north slope.

Astragalus bodinii Sheld.

Locality #59, WR 10047a, 30 June; do, WR 460, 10 July. Gravel bar, along Dog Creek. This report is apparently the first record of *A. bodinii* from Northern Yukon.

Astragalus umbellatus Bunge

Locality #4, WR 10234, 4 July; #37, WR 10091, 30 June; #59, WR 10057, 30 June. Alpine tundra and stream gravels.

Hedysarum alpinum L.

Locality #1, WR 10270, 5 July; #5, WR

10613, 13 July; #34, WR 10388; #48, WR 10520, 11 July; #51, WR 10516, 11 July; #54, WR 10277, 6 July; #67, Rigby 59, 24 June; do, WR 10116, 1 July; #76, WR 10418, 10 July; #78, Rigby 128, 26 July. Alpine tundra, on shale and limestone, and on gravel bars, stream banks and terraces, and meadows. Widespread and common. Both the dwarf alpine phase and the tall woodland phases are represented and also the intermediates between them.

Hedysarum boreale Nutt.
ssp. *mackenzii* (Richards.) Welsh

Locality #1, WR 1027a, 5 July; #12, WR 10439, 10 July; #18, Rigby 120, 25 July; #27, WR 10712, 15 July; #32, WR 10207, 3 July; #37, WR 10082, 30 June; #48, WR 10346, 9 July; #50, WR 10523, 11 July; #51, WR 10507, 11 July; #59, WR 10048, 30 June; do, WR 10467, 10 July; #67, WR 10099, 10115, 1 July. Alpine tundra on shale, limestone, and sandstone, and

FIG. 43. Southwest to the tree-fringed border of Black Fox Creek across the tundra from approximately 68°16′ N; 138°52′ W. Trail in the foreground is a winter seismograph trail. Old Crow Mountain shows very faintly along the skyline near the left border. Black Fox Creek in the foreground is at an elevation of 1100 to 1200 feet. Parkland tundra and heathland (foreground) and riparian woods in background.

on gravel bars and terraces. Widespread and locally common. There is a dwarf alpine phase in this species also, and it is likewise connected by a series of intermediates to the more robust streamside phase.

Lupinus arcticus Wats.

Locality #2, WR 10256, 5 July; #8, WR 10148, 1 July; #11, WR 10184, 1 July; #12, WR 10445, 10 July; #15, WR 10693, 15 July; #16, Rigby 43, 23 June; #24, WR 10119, 1 July; #29, WR 10740, 15 July; #59, WR 10063, 30 June; #59, WR 10066, 30 June; #62, WR 10026, 30 June; #65, WR 10303, 8 July; #77, WR 6, 18 June. Alpine tundra and heathlands on sandstone, shale, and limestone, and on stream gravels and tussock tundra. Widespread.

Oxytropis arctica R. Br.

Locality #12, WR 10448, 8 July; #35, WR 10221, 3 July; #48, WR 10340, 9 July. The latter two specimens are more or less depauperate alpine phases from limestone ridge tops, the first listed is a more typical plant from river gravels. These specimens apparently represent the first report of *O. arctica* from the Yukon since its initial collection in 1906 on Herschel Island by Lindstrom.

Oxytropis campestris (L.) DC

var. *jordalii* (Porsild) Welsh

Locality #15, WR 10572, 12 July; #59, WR 10455, 10 July. Gravel bars. Both specimens were collected from polychrome-flowered populations. The latter were pink in the field and have faded bright blue-purple as the specimens dried. The combination of small flowers, few flowered racemes, and few leaflets (17 or less) per leaf serve to unite these specimens with var. *jordalii*. This is the second know report of var. *jordalii* from the Yukon.

var. *varians* (Rydb.) Barneby

Locality #50, WR 10526, 11 July; #68, Rigby 160, 20 July; #71, WR 10494, 11 July. The first specimen cited is a dwarf alpine phase, the latter two are typical of the stream phase of var. *varians*.

Oxytropis deflexa (Pallas) DC.

var. *foliolosa* (Hook.) Barneby

Locality #59, WR 10058, 30 June; do, WR 10454, 10 July. Gravel bars. This is the first known report of *O. deflexa* for northern Yukon.

Oxytropis maydelliana Trautv.

Locality #1, WR 10266, 5 July; #32, WR 10206, 3 July; #34, WR 10494, 9 July; #36, WR 10200, 3 July; #37, WR 10089, 30 June; #46, WR 10585, 12 July; #51, WR 10513a, 11 July; #54, WR 10282, 6 July; #59, WR 10457, 10 July. Alpine tundra, on shale, slate, schist, and limestone, and gravel bars, tussock tundra and heathlands. Widespread and locally abundant.

Oxytropis nigrescens (Pallas) DC.

var. *nigrescens*

Locality #3, WR 10177, 1 July; #7, WR 10153, 1 July; #9, WR 10139, 1 July; #16, Rigby 16, 24 June; #23, Rigby 94, 25 June; #37, WR 10084, 30 June; #43, WR 10719, 15 July; #44, WR 10366, 9 July; #59, WR 10456, 10 July. Ridge tops, on limestone, sandstone, granite, shales and slates, and on stream gravels.

Oxytropis viscida Nutt.

Locality #3, WR 10173, 1 July; #6, WR 10165, 1 July; #12, WR 10441, 10 July. Gravel bars, along arctic streams, and on limestone ridge tops. This is the first report of a viscid oxytrope for northern Yukon.

Lentibulariaceae Bladderwort Family

Pinguicula vulgaris L.

Locality #15, WR 10569, 12 July; #52, WR 10483, 11 July. Wet pond margin and river bank. This is the first apparent report of *P. vulgaris* for northern Yukon.

Utricularia intermedia Hayne

Locality #52, WR 10482, 11 July. Emergent, in shallow pond, This is the first report of *U. intermedia* for northern Yukon.

Menyanthaceae Buckbean Family

Menyanthes trifoliata L.

Locality #52, WR 10486, 11 July. Emergent, in shallow ponds in Old Crow Flats.

Nymphaeaceae Waterlily Family

Nuphar polysepalum Engelm.

Locality #52, WR 10477, 11 July. Lakes, in Old Crow Flats.

Onagraceae Evening-primrose Family

Epilobium angustifolium L.

Locality #63, Rigby 113, 24 July; #69, Rigby 148, 20 July; #70, WR 10666, 15 July; #76, WR 10429, 10 July. Gravel bars, stream terraces, and lake and pond margin.

Epilobium latifolium L.

Locality #5, WR 10608, 13 July; #12, WR 10442, 10 July; #25, WR 10626, 13 July; #26,

10705, 15 July; #31, WR 10400, 9 July; #68, Rigby 153, 20 July. Stream and river gravels.

Epilobium palustre L.

var. *lapponicum* Wahl.

Locality #70, WR 10668, 15 July; #10658, 14 July. Lake margins.

Orobanchaceae Broomrape Family

Boschniakia rossica (C. & S.) Fedtsch.

Locality #28, Rigby 114, 24 July. In shrubby tundra. This is the most northern record of *B. rossica* for the Yukon.

Papaveraceae Poppy Family

Papaver radicatum Rottb.

Locality #2, WR 19242, 5 July; #4, WR 10227, 10228, 4 July; #5, WR 10614, 13 July; #18, WR 10556, 12 July; #21, Rigby 118, 25 July; #22, WR 0708, 15 July; #50, WR 10533, 11 July; #53, Rigby 112, 22 July. Ridge tops and talus slopes, on limestone, shale, and slate, and less commonly in tussock tundra.

Plantaginaceae Plaintain Family

Plantago canescens Adams

Locality #76, WR 10419, 10 July; #77, Rigby 12, 18 June. River terraces and gravel bars.

Polemoniaceae Phlox Family

Phlox sibirica L.

var. *borealis* (Wherry) Welsh

Locality #1, WR 10259, 5 July; #3, WR 10181, 1 July; #9, WR 10134, 1 July; #10, Rigby 88, 89, 25 June; #22, WR 10710a, 15 July; #35, WR 10219, 3 July; #37, WR 10090, 30 June; #48, WR 10342, 9 July. Ridge tops, on limestone, shale, slate, and sandstone, in tundra. This is the first report of *P. sibirica* for northern Yukon.

Polemonium boreale Adams

Locality #2, WR 10250, 5 July; #3, WR 10172, 1 July; #4, WR 10237, 4 July; #16, Rigby 13, 23 June; #25, WR 10625, 13 July; #26, WR 10703, 15 July; #27, Rigby 142, 28 July. Alpine tundra, on shale, slate, and limestone, and on river bars.

Polemonium caeruleum L.

var. *villosum* (Rud.) Brand

Locality #5, WR 10600, 13 July; #14, WR 10669, 15 July; #29, WR 10729, 15 July; #33, WR 10385, 9 July; #42, WR 10338, 8 July. Heathlands, willow thicket, and meadows, on gravel bars, beaches, and spits.

Polygonaceae Buckwater Family

Polygonum alpinum All.

ssp. *alaskanum* (Small) Welsh

Locality #29, WR 10734, 15 July; #69, Rigby 151, 20 July; #76, WR 10428, 10 July; #79, Rigby 132, 26 July. Gravel bars, terraces, and river bluffs and lake shores, in Old Crow Flat, and northward along the Blow River almost, or quite, to the coast. These are the first records of *P. alpinum* from northern Yukon.

Polygonum bistorta L.

ssp. *plumosum* (Small) Hulten

Locality #5, WR 10620, 13 July; #31, WR 10410, 9 July; #39, WR 10127, 1 July; #40, WR 10502, 11 July; #42, WR 10326, 8 July; #50, WR 10528a, 11 July; #56, WR 10592, 12 July; #57, WR 10072a, 30 June; #60, WR 10034. Meadows, tussock tundra, stream gravels, and taiga. Broadly distributed, common.

Rumex arcticus Trautv.

Locality #42, WR 10337, 8 July; #62 WR 10596, 13 July; #70, WR 10667, 15 July. Stream banks, and lake and pond margins. Uncommon.

Primulaceae Primrose Family

Androsace chamaejasme Host.

ssp. *lehmanniana* (Spreng.) Hulten

Locality #10, Rigby 84, 25 June; #16, Rigby 38, 23 June. River gravels and alpine tundra. Uncommon.

Dodocatheon frigidum Cham. & Schlecht.

Locality #4, WR 10230, 4 July; #39, WR 10128, 1 July; #50, WR 10534, 11 July; #54, WR 10280, 6 July; #57, WR 10079, 30 June. Meadows, stream banks, and snow flushes.

Douglasia arctica Hook.

Locality #29, WR 10742, 15 July; #41, WR 10295, 8 July; #43, WR 10718. Slaty ridge tops, in Neruokpuk formation and on gravel bars. Specimens on gravel bars grow in rounded, hemispheric clumps, those on ridge in depressed-pulvinate mats.

Douglasia ochotensis (Willd.) Hulten

Locality #4, WR 10240, 4 July; #9, WR 10137, 1 July; #17, WR 10559, 12 July. Slaty ridge tops in Neruokpuk formation, and on Lisburne limestone. This is the first report apparent of *D. ochotensis* in northern Yukon.

Pyrolaceae Wintergreen Family

Pyrola grandiflora Radius

Locality #25, WR 10629a, 13 July; #56, WR 10593a, 12 July; #60, WR 10042a, 30 June; #63, WR 10307, 8 July. Gravel bars and lake margins, in heath, thickets, and taiga.

Ranunculaceae Buttercup Family

Aconitum delphinifolium DC.

var. *delphinifolium*

Locality #5, WR 10602, 13 July; #27, Rigby 140, 28 July. Stream gravels.

Anemone drummondii Wats.

Locality #2, WR 10246, 5 July; #4, WR 10218a, 3 July; #6, WR 10168a, 1 July; #10, Rigby 87, 25 June; #48, WR 10347, 9 July. Alpine tundra, on limestone, slate, and shale, and on gravel bars along arctic streams.

Anemone parviflora Michx.

Locality #16, WR 16, 26, 37, 23 June; #40, WR 10504, 11 July; #57, WR 10075, 30 June; #59, W R10054, 30 June. Alpine tundra in meadows, and on stream gravels. Common.

Anemone patens L.

Locality #5, WR 10607, 13 July; #37, WR 10085, 30 June; #44, WR 10389, 9 July; #73, Rigby 40, 24 June. Alpine tundra, on sandstone, shale and limestone outcrops.

Anemone richardsonii Hook.

Locality #3, WR 10411, 9 July; #42, WR 10334, 8 July. Thickets and meadows, along streams.

Caltha palustris L.

var. *arctica* (R. Br.) Huth.

Locality #6, WR 10168, 1 July; #62, WR 10028a, 30 June. Pond and stream margins. Uncommon.

Delphinium glaucum Wats.

Locality #27, Rigby 139, 28 July; #71, WR 10497, 11 July. River bars and stream banks. Uncommon.

Ranunculus hyperboreus Rottb.

Locality #14, WR 10672, 15 July; #72, WR 10652, 14 July. Pond and lake margins and muddy shores.

Ranunculus lapponicus L.

Locality #30, WR 10321, 8 July. Moist willow-grass-cottongrass community. Uncommon.

Ranunculus nivalis L.

Locality #19, WR 10545, 12 July; #42, WR 10333, 8 July; #64, WR 10637, 14 July. Snow flushes, in alpine tundra, heathlands, and willow thickets. Locally common.

Ranunculus pallasii Schlecht.

Locality 62, WR 10594, 13 July. Boggy area, adjacent to Sam Lake. Uncommon.

Ranunculus pygmaeus Wahl.

Locality #42, WR 10329, 8 July; #50, WR 10535, 11 July; #64, WR 10638, 14 July. Snow flushes, in alpine tundra, heathlands, and willow thickets. Locally common.

Ranunculus turneri Greene

Locality #40, WR 10505, 11 July; #59, WR 10055, 30 June; do, WR 10463, 10 July; #64, WR 10633, 14 July. Gravel bars and thickets. Locally common.

Rubiaceae Madder Family

Galium trifidum L.

var. *trifidum*

Locality #72, WR 10653, 14 July. Lake shore, Uncommon.

Rosaceae Rose Family

Dryas integrifolia Vahl

var. *integrifolia*

Locality #6, WR 10164, 1 July; #16, Rigby 18, 36, 39, 23 June; do, Rigby 63, 24 June; #57, WR 10076a, 30 June; #60, WR 10044a, 30 June. Tundra, heathlands, and taiga. A dominant species.

Dryas octopetala L.

var. *kamtschatica* (Juz.) Hulten

Locality #5, WR 10616, 13 July; #7, WR 10159, 1 July; #33, WR 10383, 9 July; #55, WR 10067a, 30 June; #57, WR 10077, 30 June. Alpine tundra and meadows, on limestone, shale, siliceous conglomerates, and slate. A dominant species.

var. *octopetala*

Locality #10, Rigby 85, 25 June; #73, Rigby 46, 24 June. Alpine tundra. These records are apparently the first for *D. octopetala* from northern Yukon.

Geum glaciale Adams

Locality #2, WR 10244, 5 July; #4, WR 10229, 4 July; #10, Rigby 83, 25 June. Alpine tundra, on slate and shale.

FIG. 44. West along the shoreline from King Point at approximately 69°07′ N; 138°00′ W. The seacliff is in soft sediments with considerable permafrost ice showing in some of the deeper gullies. The cliff rises approximately 150 feet above the ice-covered Beaufort Sea to the right. Arctic tundra, heathland, and maritime habitat.

Potentilla anserina L.

var. *anserina*

Locality #76, WR 10527, 10 July. River bars and terraces. This is the first evident report of *P. anserina* for northern Yukon.

Potentilla biflora Willd.

Locality =5, WR 10617, 13 July; #19, WR 10551, 12 July; #46, WR 10584, 12 July; #48, WR 10519, 11 July; =53, Rigby 111, 22 July; #74, Rigby 135, 26 July. Alpine and arctic tundra, on limestone and slate.

Potentilla elegans Cham. & Schlecht.

Locality #10, Rigby 78, 25 June; #18, WR 10555, 12 July; #20, WR 10543, 12 July. Alpine

tundra, on siliceous conglomerate and sandstone. This is the first report of *P. elegans* for northern Yukon.

Potentilla fruticosa L.

Locality #5, WR 10619, 13 July; #15, WR 10566, 12 July; #42, WR 10711, 15 July; #48, WR 10521, 11 July; #50, WR 10531, 11 July; #52, WR 10481, 11 July. Taiga, heathland, and tundra. Widespread, and locally common.

Potentilla hookeriana Lehm.

Locality #5, WR 0611, 13 July; #25, WR 10627, 13 July; #33, WR 10381, 9 July; #50, WR 10525, 11 July. Alpine tundra, and along streams on gravel.

Potentilla norvegica L.

Locality #69, Rigby 149, 20 July. Lake shore This is the first report of *P. norvegica* from northern Yukon.

Potentilla palustris L.

Locality #61, WR 10289, 7 July; #70, WR 10659, 15 July; #72, WR 10656, 14 July. Lake shores, pond margins, and wet heathlands.

Potentilla uniflora Ledeb.

Locality #1, WR 19272, 5 July; #9, WR 1013, 1 July; #10, Rigby 86, 25 June; #48, WR 10343, 9 July; #55, WR 10068, 30 June; #73, Rigby 44, 24 June. Alpine tundra, on sandstone, shale, limestone, and slate. Locally abundant.

Rosa acicularis Lindl.

var. *bourgeauiana* Crepin

Locality #67, WR 10094, 1 July; #68, Rigby 155, 20 July. Gravel bars, terraces, and bluffs.

Rubus chamaemorus L.

Locality #40, WR 10505a, 11 July; #60, WR 10039, 30 June. Heathland and taiga.

Spiraea beauverdiana Schneid.

Locality #29, WR 10735, 15 July; #79, Rigby 131, 26 July. Gravel bars and gravelly slopes. This is the first report of *S. beauverdiana* for northern Yukon.

Salicaceae Willow Family

Populus balsamifera L.

Locality #27, Rigby 147, 28 July; #68, Rigby 98, 20 July; #71, WR 10499, 11 July. Gravel bars and terraces. The specimen from locality #27 is the northernmost record of this species in the Yukon.

Salix alaxensis (Anderss.) Cov.

var. *alaxensis*

Locality #6, WR 10162, 1 July; #24, WR 10118, 1 July; #36, WR 10193, 3 July; 68, Rigby 99, 20 July; #77, Rigby 21, 18 June. River and stream bars and terraces and lake shores. A dominant species in the plant community along drainages throughout the region; the tree willow of the arctic.

var. *longistylis* (Rydb.) Schneid.

Locality #77, Rigby 3, 18 June. River bar.

Salix arctica Pallas

Locality #57, WR 10075, 30 June. Meadow, in alpine tundra.

Salix brachycarpa Nutt.

ssp. *niphoclada* (Rydb.) Argus

Locality #6, WR 10163, 1 July; #11, WR 10188, 1 July; #13, WR 10694, 15 July; #31, WR 10409, 9 July; #36, WR 10196, 3 July; #50, WR 10357, 9 July; #59, WR 10064, 30 June. Alpine tundra on limestone, and arctic tundra on slate, and in tussock tundra, and on gravel bars along streams and lake shores. This entity is a dominant shrub in all major arctic plant communities.

Salix candida Flugge

Locality #52, WR 10478, 11 July. Lake margin, in wet taiga. This is the first record of *S. candida* for northern Yukon.

Salix chamissonis Anderss.

Locality #42, WR 10339, 8 July. Snow flush and meadow adjacent to willow thicket. Apparently this is the first record of *S. chamissonis* for the Yukon.

Salix fuscescens Anderss.

Locality #62, WR 10028, 30 June. Stony pavement beach of Sam Lake.

Salix glauca L.

var. *acutifolia* (Hook.) Schneid.

Locality #1, WR 10271, 5 July; #5, WR 10510, 11 July; #15, WR 10581, 12 July; #30, WR 10324, 8 July; #36, WR 10196a, 3 July; #52, WR 10664, 15 July; #60, WR 10038, 30 June; #67, WR 10107, 1 July. Lake margins, stream banks, terraces and gravel bars in tundra, heathland, and taiga. Widely distributed, common, and dominant in several plant communities.

Salix hastata L.

Locality #6, WR 10163a, 1 July; #15, WR 10567, 12 July; #25, WR 10629, 13 July; #37, WR 10404, 9 July; #54, WR 10275, 6 July; #67,

WR 10109, 1 July. Gravel bars, stream banks, and terraces. This is the first report of *S. novae-angliae* for northern Yukon.

Salix lanata L.

ssp. *richardsonii* (Hook.) Skvortsov
Locality #6, WR 10162a, 1 July. Gravel bar.

Salix phlebophylla Anderss.

Locality #8, WR 10150, 1 July; #9, WR 10145, 1 July; #25, WR 10631, 13 July; #40, WR 10501a, 11 July; #55, WR 10067, 30 June. Alpine tundra, on shale, ancient beaches, and alluvium. Widespread, and locally abundant.

Salix planifolia Pursh

ssp. *pulchra* (Cham.) Argus var. *pulchra*

Locality #11, WR 10189, 1 July; #24, WR 10121, 1 July; #30, WR 10322, 8 July; #36, WR 10195, 3 July; #62, WR 10023, 10027, 30 June; #64, WR 10635, 14 July. Lake shores, drainages, deltas, and shrubby tundra. A dominant species.

FIG. 45. Southeast along the spit at King Point along the shore of the Beaufort Sea at approximately 69°07′ N; 137°58′ W. The Richardson Mountains form the faint hills along the skyline. Major large logs in the foreground are principally conifers brought down the Mackenzie River from forests in the Northwest Territories and British Columbia to the south. Collecting locality 14.

Salix reticulata L.

Locality #16, Rigby 28, 23 June. River bank, in gravel, and in alpine tundra.

Saxifragaceae Saxifrage Family

Boykinia richardsonii Hook.

Locality #1, WR 10258, 5 July; #4, WR 10231, 4 July; #5, WR 10597, 13 July; #31, WR 10399, 9 July; #46, WR 10582, 12 July. Slopes and ridges, in alpine tundra, on slate, shale, and limestone.

Chrysosplenium tetrandrum (Lund) Fries

Locality #72, WR 10657, 14 July. Lake shore.

Chrysosplenium wrightii Franch. & Sav.

Locality #2, WR 10255, 5 July. Alpine tundra, on Kayak shale.

Parnassia kotzebuei Cham.

Locality #67, WR 10114, 1 July. Gravel bar.

Parnassia palustris L.

var. *neogoea* Fern.

Locality #15, WR 10571, 12 July; #21, Rigby 117, 25 July; #53, Rigby 110, 22 July. On limestone in alpine tundra, and with willows on gravel bars.

Saxifraga bronchialis L.

var. *purpureomaculata* Hulten

Locality #43, WR 10724, 15 July. Alpine tundra, on Neruokpuk formation. Evidently uncommon.

Saxifraga cernua L.

Locality #14, WR 10671, 15 July; #62, WR 10224, 4 July. Lake shores, and gravels along sea shores.

Saxifraga caespitosa L.

Locality #17, WR 10557, 12 July; #19, WR 10548, 12 July. Snow flushes, cliffs, and talus slopes, on Lisburne limestone. This is the first record of S. *caespitosa* for northern Yukon.

Saxifraga davurica Willd.

var. *grandipetala* (Engler & Irmscher) Welsh

Locality #2, WR 10251, 5 July; # 10236, 4 July. Alpine tundra, on shale and slate.

Saxifraga eschscholtzii Sternb.

Locality #4, WR 10213, 3 July. Alpine tundra, on Neruokpuk slate. This is the first record of S. *eschscholtzii* for the Yukon.

Saxifraga exilis Steph.

Locality #31, WR 10406, 9 July. Steep slope, with willows, on Jurassic Kingak shale.

Saxifraga flagellaris Willd.

var. *flagellaris*

Locality #9, WR 10136, 1 July; #47, Rigby 108, 22 July. Alpine tundra, on slate, shale, and limestone. This is the first record of S. *flagellaris* for northern Yukon.

Saxifraga hirculus L.

Locality #22, WR 10707, 15 July. Meadow, along Bear Creek. Evidently uncommon.

Saxifraga oppositifolia L.

Locality #23, Rigby 95, 25 June; #44, WR 10376, 9 July. Alpine tundra, on granite and limestone.

Saxifraga punctata L.

var. *nelsoni* (D. Don) Macoun

Locality #4, WR 10238a, 4 July; #11, WR 10185, 1 July; #14, WR 10669a, 15 July; #31, WR 10407, 9 July; #36, WR 10197, 3 July; #37, WR 10086, 30 June; #40, WR 10503, 11 July; #42, WR 10336, 8 July. A dominant species in tussock and shrubby tundra over a series of geological formations.

Saxifraga reflexa Hook.

Locality #1, WR 10265, 5 July; #2, WR 10252, 5 July; #3, WR 10179, 1 July; #9, WR 10144, 1 July; #16, Rigby 70, 24 June; #17, WR 10561, 12 July; #19, WR 10549, 12 July; #37, WR 0093, 30 June; #43, WR 10717, 15 July. Alpine tundra, on slate, shale, and limestone, and on stream banks.

Saxifraga rivularis L.

var. *rivularis*

Locality #42, WR 10328, 8 July. Snow flush, along a mossy bank.

Saxifraga serpyllifolia Pursh

Locality #2, WR 10253, 5 July. Alpine tundra, on Kayak shale.

Saxifraga tricuspidata Rottb.

Locality #1, WR 10268, 5 July; #9, WR 10132, 1 July; #21, Rigby 116, 25 July; #35, WR 10220, 3 July; #42, WR 10325, 8 July; #48, WR 10358, 9 July; #51, WR 10512, 11 July; #55, WR 10069, 30 June; #65, WR 10298, 1040b, 8 July; #73, Rigby 48, 24 June; #74, Rigby 136, 26 July; #75, Rigby 146, 26 July. A dominant species in alpine tundra, in several communities.

Scrophulariaceae Figwort Family

Castilleja elegans Malte

Locality #78, Rigby 122, 26 July. Gravelly bluff.

Castillepa hyperborea Pennell

Locality #22, WR 10710, 15 July; #37, WR 10088a, 30 June; #43, WR 10723, 15 July; #44, WR 10373, 9 July; #46, WR 10583, 12 July; #47, Rigby 105, 22 July; #58, WR 10447, 11 July. Alpine tundra ridge tops, on limestone, sandstone, slate, and shale. Locally common.

Castilleja pallida (L.) Spreng.

ssp. *caudata* Pennell

Locality #13, WR 10695, 15 July; #15, WR 10573, 12 July; #31, WR 10403, 9 July; #54, WR 10274, 6 July; #59, WR 10056, 30 June; do, WR 10466, 10 July; #67, WR 10100, 1 July. Gravel bars, terraces, and bluffs, and less commonly in tundra.

Castilleja raupii Pennell

Locality #70, WR 10665, 15 July. Pond margin, in heath-taiga vegetation. Apparently, this is a new record for northern Yukon.

Lagotis glauca Gaertn.

Locality #3, WR 10170, 1 July; #4, WR 10235, 4 July; #10, Rigby 93, 25 June; #11, WR 10183, 1 July; #24, WR 10124, 1 July; #37, WR 0088, 30 June; #57, WR 10073, 30 June; #62, WR 10029, 30 June. Meadows, lake margins, tussock tundra, and ridge tops, on shale, slate, and limestone.

Pedicularis capitata Adams

Locality #1, WR 10267, 5 July; #3, WR 10174, 1 July; #7, WR 10155, 1 July; #11, WR 10186, 1 July; #13, WR 10691, 15 July; #30, WR 10320, 8 July; #37, WR 10087, 30 June; #50, WR 10528, 11 July; #57, WR 10281, 6 July; #62, WR 10030a, 30 June; #65, WR 10299, 8 July. Tussock tundra, meadows, and deltas, on sandstone, shale, limestone, slate, and alluvium. Common. A dominant species.

Pedicularis kanei Durand

Locality #1, WR 10272a, 5 July; #16, Rigby 17, 32, 23 June; do, Rigby 67, 24 June; #44, WR 10372, 9 July; #57, WR 10072, 30 June. Alpine tundra and with willows along stream banks.

Pedicularis labradorica Wirsing

Locality #33, WR 10382, 9 July; #47, WR 10360, 9 July; #48, WR 10520a, 11 July; #52, WR 10480, 11 July; #60, WR 10040, 30 June; #61, WR 10288, 7 July; #65, WR 10302, 8 July.

FIG. 46. Elf icefield along the headwaters of Canoe River. Kayak Shale forms the low dark exposures along the river and is capped by light colored Lisburne Limestone. Cretaceous rocks form the steeply dipping cuestas along the skyline in the background. As ice field melts, willows encased in it grow leaves, produce flowers, and fruit. Tussock tundra and heathlands.

Tussock tundra, heathlands, and taiga, and alpine tundra on ridge tops and rock stripes, on siliceous conglomerate, limestone, and sandstone.

Pedicularis langsdorfii Fisch.

Locality #13, WR 10690, 15 July; #14, WR 10684, 15 July; #24, WR 10125, 1 July; #30, WR 10316, 8 July; #57, WR 10283, 6 July; #62, WR 10025, 30 June; #63, WR 10309, 8 July; #64, WR 10634, 14 July; #65, WR 10304, 8 July. Lake shores, heathlands, wet meadows, tussock tundra, stream banks, deltas, and spits.

Pedicularis oederi Vahl.

Locality #10, Rigby 76, 25 June. Alpine tundra.

Pedicularis sudetica Willd.

var. *bicolor* Walpers

Locality #14, WR 10683, 15 July; #30, WR 10317, 8 July; #60, WR 10043, 30 June; #62, WR 10222, 10222a, 4 July; #63, WR 10308, 5 July. Lake shores, stream banks, and deltas, in heathland, tundra, and taiga.

var. *gymnocephala* Trautv.

Locality #52, WR 10488, 11 July. Wet heathland, in taiga. This is the first report of these two varieties for northern Yukon.

Pedicularis verticillata L.

Locality #15, WR 10568, 12 July. Gravel bar, with willow and dwarf birch.

Umbelliferae Carrot Family

Bupleurum triradiatum Arams

ssp. *arcticum* (Regel) Hulten

Locality #33, WR 10387, 9 July; #34, WR 10398, 9 July; #43, WR 10715, 15 July; #44, WR 10374, 9 July; #48, WR 10349, 9 July; do, WR 10519a, 11 July; #66, Rigby 104, 22 July. Alpine tundra, on siliceous conglomerate, limestone, slate, and shale.

Conioselinum cnidifolium (Turcz.) Porsild

Locality #76, WR 10433, 10 July. River terrace, in white spruce woods.

Valerianaceae Valerian Family

Valeriana capitata Pallas

Locality #5, WR 10599, 13 July; #10, WR 10190, 1 July; #14, WR 10689, 15 July; #25, WR 10628, 13 July; #33, WR 10384, 9 July; #51, WR 10507, 11 July; #60, WR 10035, 30 June. Tundra, heathland, and taiga.

PTEROPSIDA-ANGIOSPERMAE-MONOCOTYLEDONAE

Cyperaceae Sedge Family

Carex aquatilis Wahl.

ssp. *aquatilis*

Locality #15, WR 10575, 12 July; #52, WR 10484, 11 July; #62, WR 10031, 30 June; #70, WR 10661, 15 July. Emergent in shallow ponds and lakes, and on lake shores, gravel bars, and stream banks. This is the first report of ssp. *aquatilis* from northern Yukon.

Carex bigelovii Torr.

Locality #14, WR 10680, 15 July; #31, WR 10412, 9 July; #36, WR 10198, 3 July; #40, WR 10506a, 11 July; #42, WR 10327, 8 July; #56, WR 10588, 12 July; #57, WR 10077a, 30 June; #60, WR 10037, 30 June; #61, WR 10285, 7 July; #65, WR 10303a, 8 July. A dominant species in tussock tundra, and on rockstripes and outcrops of sandstone and limestone, and on gravel bars and spits.

Carex capillaris L.

Locality #15, WR 10574, 12 July. Gravel bar, with willow and dwarf birch. This is the first report of *C. capillaris* for northern Yukon.

Carex chordorrhiza Ehrh.

Locality #52, WR 10489, 11 July. Emergent in shallow ponds, in wet heath-taiga.

Carex concinna R. Br.

Locality #54, WR 10278, 6 July. Wet meadow.

Carex diandra Schrank

Locality #52, WR 10485, 11 July. Emergent in margin of shallow lake. This is the first record of *C. diandra* from northern Yukon.

Carex limosa L.

Locality #52, WR 10491, 11 July. Emergent, in shallow water, in wet heath-taiga. This is the first record of *C. limosa* for northern Yukon.

Carex macloviana d' Urville

Locality #40, WR 10504a, 11 July. Gravel bar. The specimen is fragmentary but apparently belongs to *C. macloviana*, and is the first record of the species for northern Yukon.

Carex maritima Gunn.

Locality #61, WR 10287, 7 July. Shallow pond, in polygonal tundra.

Carex misandra R. Br.

Locality #19, WR 10546a, 12 July; #44, WR

10371, 9 July. Limestone outcrops, in alpine tundra. This is the first record of *C. misandra* for northern Yukon.

Carex nardina Fries

Locality #11, WR 10188a, 1 July; #17, WR 10560, 12 July; #44, WR 10375, 9 July. Limestone and slate ridge tops, in alpine tundra.

Carex petricosa Dewey

Locality #15, WR 10576, 12 July; #19, WR 10546, 12 July. Limestone, in alpine tundra, and on gravel bar in stream course.

Carex podocarpa R. Br.

Locality #7, WR 10156, 1 July; #9, WR 10146, 1 July; #20, WR 10542, 12 July; #24, WR 10122, 1 July; #41, WR 10290, 8 July; #43, WR 10726, 15 July; #64, WR 1063a, 10645, 14 July. On slate, conglomerate, and sandstone; in alpine tundra, and in tussock tundra, heathlands, lake shores, stream banks, and gravel bars. A dominant species.

Carex rotundata Wahl.

Locality #61, WR 10286, 7 July. Emergent in shallow pond, in polygonal tundra. This is the first report of *C. rotundata* for northern Yukon.

Carex rupestris All.

Locality #34, WR 10394, 9 July; #46, WR 10587, 12 July. Limestone and slate ridgetops, in alpine tundra.

Carex scirpoidea Michx.

Locality #15, WR 10578, 12 July; #44, WR 10368, 9 July; #46, WR 10586, 12 July; #52, WR 10493, 11 July. Lake shores and river bars, in heath and taiga, and on limestone and slate in alpine tundra.

Carex supina Willd.

ssp. *spaniocarpa* (Steud.) Hulten

Locality #47, WR 10361, 9 July. Siliceous conglomerate rock stripes in alpine tundra. This is the first report of *C. supina* for northern Yukon.

Eriophorum angustifolium L.

Locality #30, WR 10314, 8 July; #52, WR 10490, 11 July; #62, WR 10311, 8 July; do, WR 10030, 30 June; #72, WR 10650, 14 July. Lake and pond margins.

Eriophorum chamissonis C. A. Mey.

var. *albidum* (Myl.) Fern.

Locality #30, WR 10318, 8 July. Delta of Blow River, This is the first report of *E. chamissoni* for northern Yukon.

Eriophorum scheuchzeri Hoppe

Locality #62, WR 10225, 4 July; #72, WR 646, 14 July. Lake shores. This is the first report of *E. scheuchzeri* for northern Yukon.

Eriophorum vaginatum L.

Locality #24, WR 10120, 1 July; #63, WR 10310, 8 July; #64, WR 10632, 14 July. A dominant species in the tussock tundra. By mid-July, the tundra appeared to be covered by hoarfrost due to the abundant inflorescences of *E. vaginatum*. This is the first record of *E. vaginatum* for northern Yukon.

Kobresia myosuroides (Ville.) Fiori & Pavl.

Locality #11, WR 10187a, 1 July; #34, WR 10392, 9 July. Alpine tundra, on slate and limestone.

Scirpus caespitosus L.

Locality #52, WR 10492, 11 July. Lake shore. This is the first report of S. *caespitosus* for northern Yukon.

Gramineae Grass Family

Agropyron caninum (L.) Beauv.

var. *latiglume* (Scribn. & Sm. Pease & Moore

Locality #12, WR 10451, 10 July; #59, WR 10471, 10 July; #76, WR 10431, 10 July. Stream gravels and river terraces.

Agropyron macrourum (Turcz.) Drobov

Locality #26, WR 10697, 15 July; #31, WR 10413, 9 July; #59, WR 10472, 10 July; #67, WR 10098, 10103, 10112, 1 July; #76, WR 10421, 10 July. Terraces and gravel bar.

Alopecurus alpinus Sm.

Locality #14, WR 10677, 15 July; #30, WR 10315, 8 July. Spits, beaches, and deltas along the Beaufort Sea. This is the first record for northern Yukon.

Arctagrostis latifolia (R. Br.) Griseb.

Locality #15, WR 10577a, 12 July; #29, WR 10733, 15 July; #56, WR 10589, 12 July; #72, WR 10648, 14 July. Gravel bars and lake shores.

Arctophila fulva (Trin.) Anderss.

Locality #62, WR 10312, 8 July; do, WR 10595, 13 July; #72, WR 10651, 14 July. Emergent in shallow lakes and ponds.

Bromus pumpellianus Scribn.

Locality #12, WR 10450, 10 July; #26, WR 10702, 15 July; #32, WR 10212, 3 July; #71, WR 10498, 11 July; #76, WR 10434, 10 July.

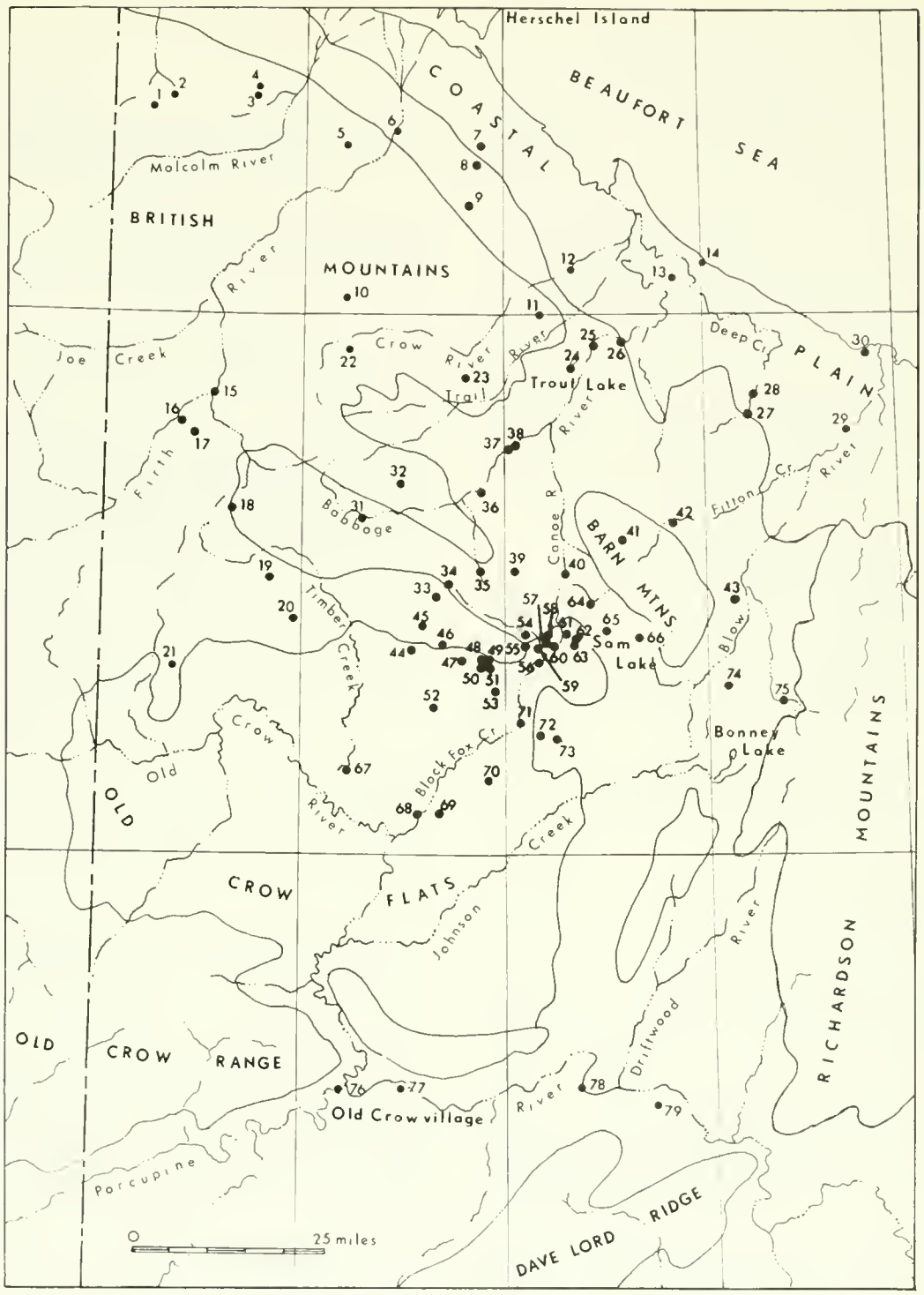

Fig. 47. Map of collection localities in northern Yukon.

Stream terraces and gravel bars, and less commonly on sandstone in alpine tundra.

Calamagrostis canadensis (L.) Beauv.

Locality #68, Rigby 152, 20 July. Gravel bar. This is the first report of *C. canadensis* for northern Yukon.

Calamagrostis inexpansa Gray

Locality #15, WR 10577, 12 July; #29, WR 10745, 15 July. Gravel bars. This is the first record of *C. inexpansa* for northern Yukon.

Calamagrostis purpurascens R. Br.

Locality #21, Rigby 121, 25 July; #34, WR 10396, 9 July; #48, WR 10351, 9 July; #68, Rigby 102, 20 July. Gravel bars, and on rocky limestone outcrops in alpine tundra. This is the first report of *C. purpurescens* for the northern Yukon.

Deschampsia caespitosa (L.) Beauv.

Locality #29, WR 10732, 15 July; #31, WR 10416, 9 July. Gravel bars.

Elymus innovatus Beal

Locality #2, WR 10248, 5 July; #15, WR 10579, 12 July. Gravel bars, and on shaly slopes in alpine tundra.

Elymus mollis Trin.

Locality #14, WR 10676, 15 July. Sea beach and spit.

Festuca altaica Trin.

Locality #31, WR 10417, 9 July. Stream bank.

Festuca baffinensis Polunin

Locality #29, WR 10731, 10743, 15 July. Gravel bar. This is the first report of *F. baffinensis* for northern Yukon.

Festuca brachyphylla Schult.

Locality #17, WR 10558a, 12 July; #44, WR 10370, 9 July. Limestone outcrops, in alpine tundra.

Festuca rubra L.

Locality #12, WR 10449, 10 July; #25, WR 10630, 13 July; #26, WR 10696, 15 July; #56, WR 10593, 12 July; #59, WR 10473a, 10 July; #68, WR 101, 20 July. Gravel bars. This is the first record of *F. rubra* for northern Yukon.

Hierochloe alpina (Sw.) R. & S.

Locality #7, WR 10157, 1 July; #18, WR 10553, 12 July; #29, WR 10747, 15 July; #42, WR 10330, 8 July. A dominant species in alpine and dry tussock tundra, on slate, sandstone, and alluvium.

Hordeum jubatum L.

Locality #76, WR 10422, 10 July. River terrace, in open white spruce woods. This is the first record of *H. jubatum* for northern Yukon.

Poa alpigena (Fries) Lindm.

Locality #76, WR 10438, 10 July. River bar, with other grasses and forbs.

Poa alpina L.

Locality #10, Rigby 92, 25 July. Alpine tundra, on Kayak shale.

Poa arctica R. Br.

Locality #29, WR 10730, 15 July; #34, WR 10396a, 9 July; #45, WR 10540, 12 July; #59, WR 10469, 10474a, 10 July; #65, WR 10305, 8 July. Gravel bars, and in alpine tundra on sandstone, siliceous conglomerate and limestone.

Poa glauca Vahl

Locality #9, WR 10130, 1 July; #29, 10741, 15 July; #42, WR 10296, 8 July; #43, WR 10728, 15 July; #44, WR 10377, 9 July; #59, WR 10470, 10 July; #74, Rigby 138, 26 July. Alpine tundra, on limestone and shale, and on gravel bars.

Poa lanata Scribn. & Merr.

Locality #29, WR 10730a, 15 July; #72, WR 10647, 14 July. Gravel bars and lake shores. This is the first record for northern Yukon.

Puccinellia borealis Swallen

Locality #14, WR 10678, 10678a, 10679, 15 July; #76, WR 10437, 10 July. River bars and terraces, and sea beaches and spits.

Trisetum spicatum (L.) Richt.

var. *molle* (Michx.) Beal

Locality #19, WR 10547, 12 July; #29, WR 10746, 15 July; #31, WR 10415, 9 July; #43, WR 10727, 15 July; #59, WR 10474, 10 July. Gravel bars, and in alpine tundra on slate and limestone.

Juncaginaceae Arrowgrass Family

Triglochin maritima L.

Locality #52, WR 10487, 11 July. Wet heath-taiga around a small lake.

Juncaceae Rush Family

Juncus arcticus Willd.

Locality #31, WR 10414, 9 July. Gravel bar.

This is the first report of *J. arcticus* for northern Yukon.

Juncus triglumis L.

Locality #52, WR 10490, 11 July. Wet heathland, surrounding a small lake. This is the first record of *J. triglumis* for northern Yukon.

Luzula confusa Lindeb.

Locality #41, WR 10294, 8 July; #42, WR 10335, 8 July; #45, WR 10541, 12 July; #65, WR 10304a, 8 July. Alpine tundra.

Liliaceae Lily Family

Allium schoenoprasum L.

var. *sibiricum* (L.) Hartm.

Locality #5, WR 10598, 13 July; #77, Rigby 1, 6, 10, 18 June; #78, Rigby 124, 26 July. Gravel bars and terraces. This is the first report for northern Yukon, and the Loney Creek locality is apparently the only one known for the species on the north slope.

Tofieldia pusilla (Michx.) Pers.

Locality #50, WR 10537, 11 July; #54, WR 10279, 6 July. Meadows and alpine tundra, on gravel and on shale and limestone.

Zygadenus elegans Pursh

Locality #5, WR 10609, 13 July; #15, WR 10571a, 12 July; #21, Rigby 119, 25; #22, WR 10709, 15 July; #50, WR 10522, 11 July; #51, WR 10511, 11 July; #71, WR 10497a, 11 July. Gravel bars, and in alpine tundra on shale and limestone.

Potamogetonaceae Pondweed Family

Potamogeton alpinus Balbis

var. *tenuifolius* (Raf.) Ogden

Locality #70, WR 10660, 15 July. Shallow pond. This is the first report of *P. alpinus* for northern Yukon.

	Lycopsida	Sphenopsida	Filicineae	Gymnospermae	Dicotyledoneae	Monocotyledoneae	Total
Families	2	1	1	1	31	6	42
Genera	2	1	2	2	98	25	125
Species	2	2	2	2	203	68	279
Subspecies					15		15
Varieties					63		63
Formae					1		1

Fig. 48. Summary of taxa collected in northern Yukon.

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by

Samuel R. Rushforth

BIOLOGICAL SERIES — VOLUME XIV, NUMBER 3

SEPTEMBER 1971

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TABLE OF CONTENTS

	Page
INTRODUCTION	1
GEOLOGICAL BACKGROUND	1
Lithological Characteristics	1
Geology	4
THE AGE OF THE DAKOTA SANDSTONE	4
A CONCEPT OF A DAKOTA FLORA	7
PALEOECOLOGY	9
PALEOCLIMATE	12
SYSTEMATICS	13
Genus *Equisetum*	13
Genus *Asplenium*	14
Genus *Coniopteris*	18
Genus *Hausmannia*	18
Genus *Gleichenia*	20
Genus *Matonidium*	27
Genus *Astralopteris*	34
Genus *Cladophlebis*	34
Genus *Ilex*	38
Genus *Magnolia*	38
Genus *Ficus*	38
Genus *Eucalyptus*	40
Genus *Platanus*	42
Genus *Salix*	42
ACKNOWLEDGEMENTS	42
REFERENCES CITED	43

A FLORA FROM THE DAKOTA SANDSTONE FORMATION (CENOMANIAN) NEAR WESTWATER, GRAND COUNTY, UTAH

by

Samuel R. Rushforth[1]

ABSTRACT

A Cretaceous (Cenomanian) flora from the Dakota Sandstone Formation near Westwater, Grand County, Utah contains an admixture of ferns and angiosperms. The ferns of this flora are representative of an older Jurassic-Wealden vegetational type, whereas the angiosperms are typical of the modern vegetational type. Species of *Gleichenia* and *Matonidium* and *Astralopteris coloradica* represent the dominant forms in this flora.

The Westwater flora contains fourteen genera including nineteen species and one variety. New species described from this flora include *Asplenium dakotensis*, *Coniopteris westwaterensis* and *Ilex serrata*.

INTRODUCTION

A fern-angiosperm flora from the Cretaceous (Cenomanian) Dakota Sandstone Formation has been under study for some time. This flora was collected from an ash seam and sandstone in the Dakota Sandstone Formation from Rabbit Valley, Grand County, Utah, and along the road and surrounding areas between U.S. Highway 50 and Westwater, Grand County, Utah.

This Dakota flora is significant for three reasons. First, it contains several new species of fossil plants. Second, it extends the known distribution patterns of many previously described species. The Westwater flora is one of few paleofloras which illustrates an admixture of an older Jurassic-Wealden floristic type with a modern angiospermous floral type. Third, this flora provides new information on a time of the earth's history when angiosperms were expanding from a position of little floristic importance to a position of dominance in Cretaceous and later floras.

GEOLOGICAL BACKGROUND

Lithological Characteristics.— Two early workers, Marcou (1864) and Capellini (Capellini and Heer, 1867), considered the Dakota Group of Meek and Hayden (1856, 1861) to have been deposited in fresh water. This determination was based primarily upon the included leaf flora. However, Hayden (1867) stated that together with F.B. Meek, he had collecetd well-preserved marine invertebrate remains mingled with the leaves of the Dakota Group. Hayden concluded that the Dakota Group was marine in origin. This conclusion was adhered to by Lesquereux (1874, and others) and by subsequent workers.

Lesquereux (1874) presented an excellent discussion on the probable origin of the Dakota Group. Based upon studies of recent depositional facies and comparing them to the Dakota, Lesquereux stated: "They are beach formations, like those in progress at the present time along the shore of the North Sea, in Holland and Belgium, where the widely extended muddy shores are formed of a soft substance of the red color." Lesquereux further mentioned that the presently forming North Sea beaches are characteristic and similar to Dakota beds by being composed of sands borne by the sea intermixed with muds borne by the sea inter-

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mixed with muds borne by nearby rivers. In mentioning that the leaves of some species often exhibit a clumped rather than a random distribution in Dakota strata, Lesquereux (l.c.) postulated:

> A distribution of this kind can result only from the proximity of the trees from which the leaves have been derived, and confirms the opinion that the formation of the Dakota group is the result of muddy flats whose surface, raised perhaps in hillocks above water-limits, and already solid ground, was cut like an immense swamp, here and there interspersed by rare groups of trees and bushes.

In support of Lesquereux's hypothesis, it should be mentioned that within the Dakota Sandstone Formation there are deposits indicative of fresh and brackish water. Evidence for this comes from lignite seams, fossil assemblages, stratigraphy and lithology. These sediments could have been deposited in embayments, estuaries, and on flood plains (Chaney, 1954; Repenning and Page, 1956.). However, because of frequent lignite beds and carbonaceous shales, and the great number of leaf impressions, which, due to their excellent state of preservation, do not appear to have been transported for any great distance, these deposits appear to have been laid down in paludal environments close to the sea, similar to those described by Lesquereux (1874).

In discussing the nomenclature used in connection with the Dakota Sandstone (as used by Meek and Hayden, 1856, 1861), Tester (1931) preferred the useage of the term Dakota Stage. His reasoning for the application of this term sheds some light on the nature of the beds referred to the Dakota Sandstone. Tester stated in part:

> Geologic events which are of considerable magnitude, and which have some effect over a large area, or which constitute a normal progression of rocks, are considered responsible for the deposition of rocks comprising a stage. The widespread marine advance, with its shoreline variations due to minor retreats and advances of the waters and to the lands being built out into the oceans, or the migration of faunas and shifting of ocean currents, all have their effect on the character of the rocks. The rocks deposited under such conditions on an extensive scale, as they were during Dakota time, are classed as a stage. It might be said that a stage is indicative of a set of conditions of rock deposition rather than of a distinct lithological or paleontological division.

From Tester's discussion, several important concepts are apparent. First, the geologic event responsible for the deposition of the Dakota Sandstone was of considerable magnitude and had effect over a large area. Second, this geological event was the extensive marine advance during Dakota times. Third, the Dakota Sandstone Formation indicates a set depositional characteristics rather than conforming to a distinct lithological or paleontological division.

From the foregoing discussion, a working definition of the Dakota Sandstone Formation may be given. This formation is a Cretaceous time transgressive sequence of marine, fresh or brackish water, clastic sediments of various colors (with red, yellow, and white being common) deposited under fluvial and paludal conditions, often with interbedded lignite, shale and ash sequences. This formation can not be defined on the basis of paleontological similarities, although included fossil plants may be correlated to some extent. Strata comprising the Dakota Sandstone Formation are related throughout their geographical extent in that they were similarly deposited as the result of the invading Cretaceous sea. The Dakota Sandstone Formation exhibits continuity throughout much of the western and midwestern United States, authough sediments of this formation from different regions need not be of the same age due to the deposition of Dakota strata at the edge of a coastline which changed with time.

Tester (1931) pointed out that a wide variety of names had been used for discussing Dakota strata including Dakota Group (originally used by Meek and Hayden in 1861 in referring to their Formation No. 1 of 1856), Dakota Series, Dakota Stage, Dakota Formation, Dakota Sandstone, and Dakota without any additional term. Tester (1931) preferred the use of Dakota Stage which he used synonymously with the term group, since he restricted the usage of group for the rocks of an entire era.

The term group or stage usage is useful in delimiting the rocks of more than one closely related formation when the distinction between them is either difficult or unnecessary. However, later workers (Jenney, 1899; Darton, 1905; Stanton, 1905) showed that the Dakota Group of the Black Hills and Rocky Mountain regions could be divided into Lower and Upper Cretaceous formations; these workers restricted the Dakota Sandstone to formational status. Furthermore, the original Dakota Group from the midwestern United States is similar stratigraphically and floristically (although some variation may be noted in floras from different regions) to the restricted Dakota Sandstone

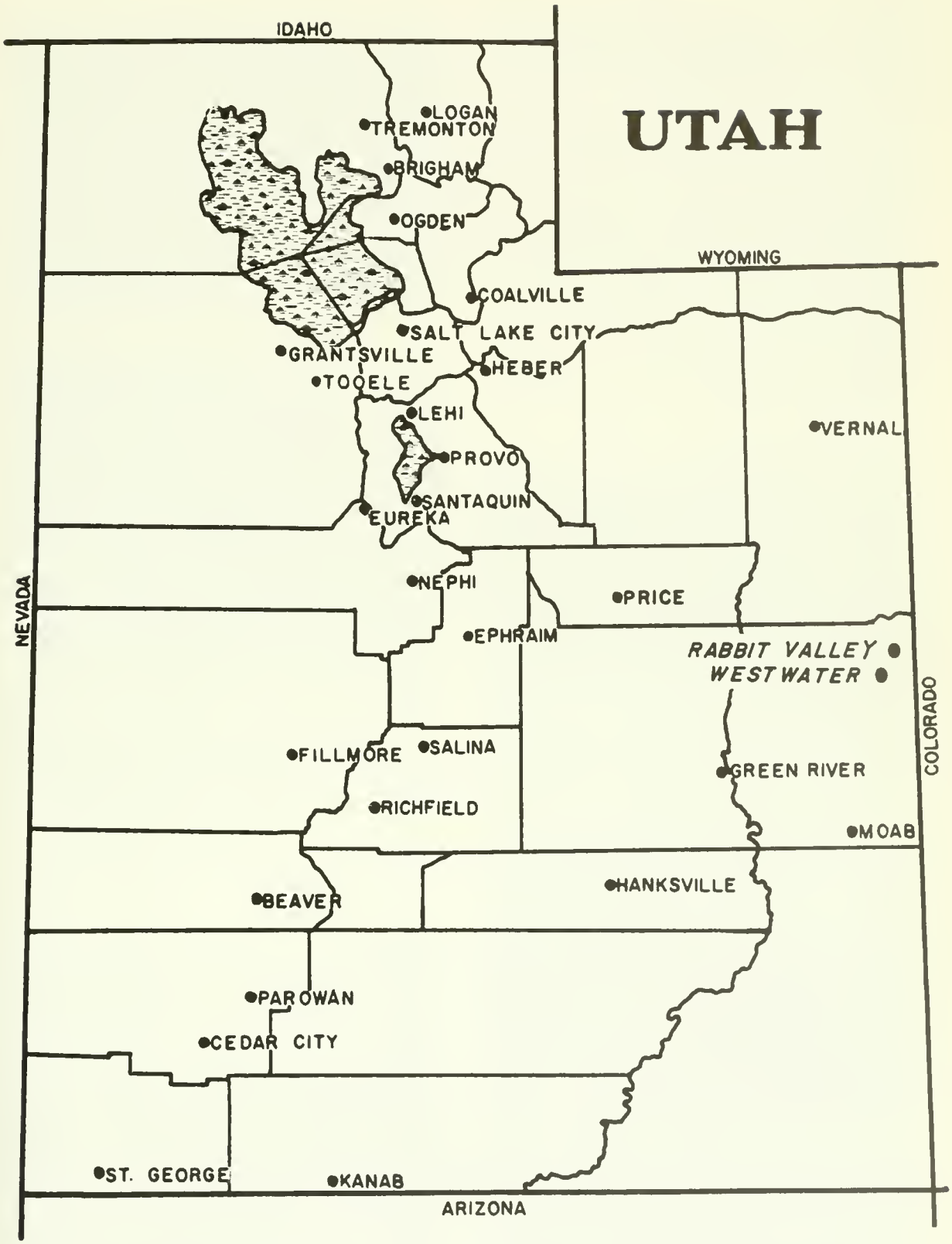

Fig. 1. Index map of collecting localities.

Formation of the Black Hills and Rocky Mountain regions. In light of this, the term Dakota Sandstone Formation will be used by the author for discussion of Dakota strata.

GEOLOGY.—Stanton (1905) in working with the Jurassic Formation and its relationship with the Comanche Series and the Dakota Formation in Southern Colorado, New Mexico, and Oklahoma, demonstrated that the Dakota Sandstone of this region, as originally defined, contains both Lower and Upper Cretaceous strata. Thus, Stanton pointed out that the true Dakota Sandstone Formation of these widely separated regions overlies Lower Cretaceous deposits which overlie the Morrison Formation.

Similar conditions have been observed in several other regions of the western United States. In Montrose County, Colorado, the Dakota Sandstone Formation occupies a position between the Jurassic Morrison Formation (McElmo Formation of Coffin, 1921) and Upper Cretaceous Mancos Shale Formation. Careful examination of these strata (Coffin, 1921) indicated that the Jurassic Morrison Formation is overlain by a Lower Cretaceous sequence. This sequence was given formational status by Coffin (1921) who named it the Post-McElmo Formation. Stokes (1948) changed the name of this Lower Cretaceous sequence to the Burro Canyon Formation.

Plants of this Lower Cretaceous sequence in Colorado were studied by Brown (1950). Brown concluded that floristic evidence agreed with the findings of Coffin (1921). A Lower Cretaceous flora was described by Brown from the Burro Canyon Formation, and a somewhat atypical Dakota flora was described from the Dakota Sandstone Formation. This Dakota flora is atypical in that the incidence of ferns with angiosperms is high.

Jurassic and Cretaceous stratigraphy near Westwater, Grand County, Utah, is similar to that of Montrose County, Colorado. The Jurassic Morrison Formation from this region of Utah is overlain by the Lower Cretaceous Cedar Mountain Formation. This formation is correlated to the east with the Burro Canyon Formation. However, no plants have been collected from the Cedar Mountain Formation of Grand County. This Lower Cretaceous formation is overlain by the Dakota Sandstone Formation (Plate 3.) This formation from this region is composed of three lithological units. The basal unit is a massive, buff-colored sandstone of approximately thirty feet in thickness. This unit is overlain by a shale-coal-sand sequence which is approximately thirty feet thick. Fossil plants collected near Westwater are obtained from this unit. This shale-coal-sand unit is in turn overlain by a massive buff-colored sandstone unit. This is the uppermost unit of this formation near Westwater, and it is approximately thirty to forty feet in thickness. This formation is overlain by the Upper Cretaceous Mancos Shale Formation. Most leaf compressions collected from the Dakota of this region are obtained from an ash seam approximately forty to forty-five feet beneath the *Gryphaea newberryi* zone in the overlying Mancos Shale.

THE AGE OF THE DAKOTA SANDSTONE

Much of the earliest work concerning the Dakota Sandstone Formation was concerned extensively with the age of these rocks. Briefly, the Dakota was the first considered as a Cretaceous group (Meek and Hayden, 1856, 1858). This interpretation was refuted by Hawn (1858) who supposed that Dakota strata belonged in the Triassic. Heer (1859, 1861) proposed that the Dakota was of Tertiary age, and Marcou (1858) stated that the original Dakota was composed of rocks of both Tertiary and Jurassic age. Later work (Marcou, 1864; Capellini and Heer, 1867) demonstrated that Dakota rocks indeed belong to the Cretaceous, as originally postulated by Meek and Hayden. This age determination has been adhered to by all following workers, and the only subsequent controversy has been concerning the proper Cretaceous epoch to which Dakota strata should be assigned.

An accurate ascertainment of the age of the Dakota Sandstone Formation (whether early or late Cretaceous) has been complicated by two problems. The first concerns a poor usage of the term, "Dakota flora." This term has been used loosely by some workers, and as pointed out by Berry (1920), "Any Cretaceous formation containing dicotyledonous leaves and known or thought to be older than the Benton . . ." was said to contain a Dakota flora. In other words, Dakota flora became an adjectival term rather than delimiting a flora which had been ob-

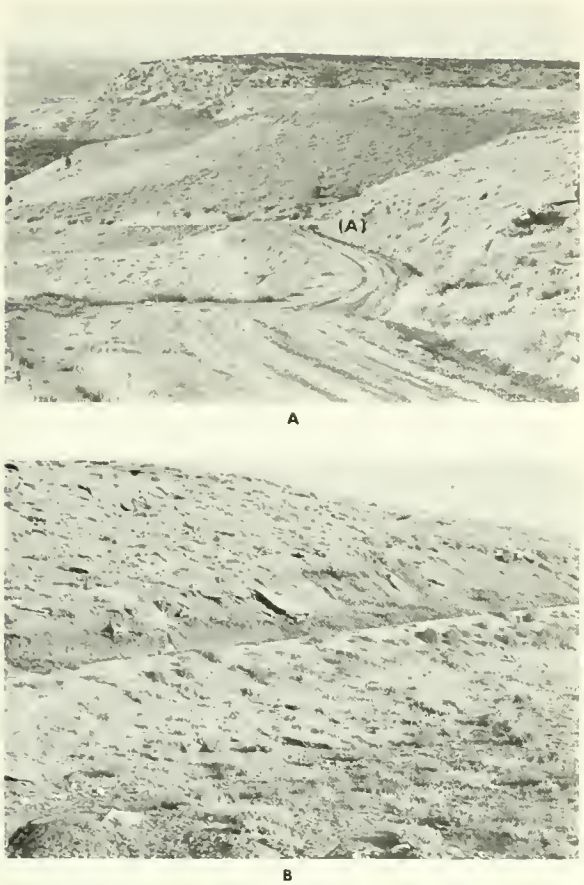

Fig. 2. A. Southeast view down canyon towards Westwater, Grand County, Utah. The Dakota Sandstone Formation forms the hills and slopes in the foreground and is exposed along the roadcut. Original collections from the Dakota Sandstone of this region were made in the roadcut (A). The Mancos Shale Formation overlies the Dakota in this region. B. Close-up of collecting site (A) in Fig. 1. This site yielded the best colections of fossil plants from this area.

tained from the Dakota Sandstone. This problem became so acute that Berry (1920) further stated, "It has become increasingly clear of late years that Dakota flora was not a unit and had no precise stratigraphic value." Berry (1920) proposed that in order to eliminate this problem, a true Dakota flora may be defined as "meaning thereby the equivalent of that of the Woodbine Formation of Texas, and those of corresponding age elsewhere. . . ." This interpretation, however, has one inherent difficulty. That is, it does not allow for the possibility that within the same formation, fossil assemblages may differ sufficiently to render their comparison with the flora from another formation difficult. This may result either from a nonrandom geographical distribution of fossils within the formation or from evolutionary changes in plant communities over a period of time synchronous with deposition.

An alternative to the proposal of Berry (1920) is that in delimiting a true Dakota flora, only plants from the Dakota Sandstone Formation be considered. That is, the only valid application of the term Dakota flora can be in the discussion of plants from the Dakota Sandstone **sensu stricto.** It is neither valid nor prudent to delimit a Dakota flora, merely in the sense of a Cretaceous dicotyledonous flora, from any other geological entity.

This suggestion, however, leads to a discussion of the second problem which is somewhat less easily treated. It is that the Dakota Sandstone is a time transgressive formation and

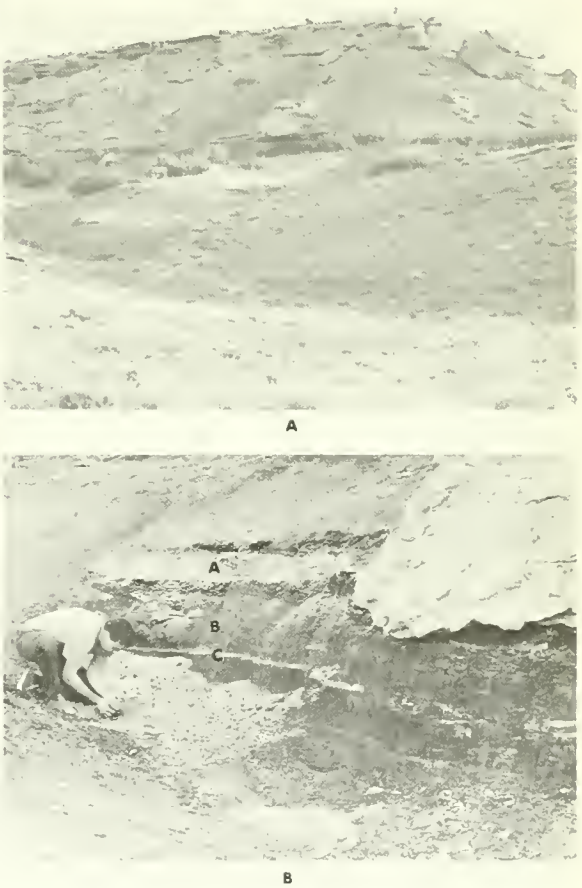

Fig. 3. A. Overview of Dakota Sandstone Formation showing massive upper sandstone unit resting upon shale-coal-sand unit. The arrow points to a collecting excavation. B. Close-up of excavation in Fig. 1 illustrating lithology of shale-coal-sand unit. The upper coal (B) and unfossiliferous ashes (A and C) have been removed in this excavation exposing the fossiliferous ash upon which the worker is kneeling.

was deposited over a range of time that witnessed a vast floristic change in the dominant vegetation of the earth. That is, although all formations are time transgressive, many are deposited within a period of time wherein little change in the contemporaneous flora or fauna occurred, and therefore the included fossils of that formation would be expected to exhibit homogenity. However, the Dakota Sandstone Formation was deposited over a period of time when the predominant vegetational type of the earth changed from a fern-gymnosperm alliance typical of the older Mesozoic to an angiosperm dominated flora typical of the Late Cretaceous, Tertiary, and present times. Therefore it is possible to collect within this formation, fossil assemblages which appear to be indicative of different ages. This is particularly the case when the Dakota Sandstone Formation from west and east of the Rocky Mountains are compared, and the floras from the western portion of this formaton appear to be older than their counterparts from the east. Further discussion on both microfloral and megafloral evidence bearing on this situation will be considered later.

Earliest detailed estimates (Lesquereux, 1874, 1883, 1892) concerning the age of the Dakota Sandstone Formation placed it as Cenomanian. This concept has been generally adhered to since that time, although some geolgists have disagreed with it based chiefly upon stratigraphy. In connection with this, Twenhofel (1920) assigned the Dakota to a Lower Cretaceous age. Tester (1931) in studying the type locality of the Dakota Sandstone considered it to be older than Cenomanian and placed Washita-Kiowa-Mentor-Dakota rocks of Kansas at the base of the Cretaceous, with the Dakota being at least as old as the Mentor Formation of this region (midAlbian). However, the conclusions of Twenhofel and Tester were drawn based upon stratigraphic evidence alone and are not substantiated by floristic evidence.

Cobban and Reeside (1952) assigned the Dakota Group to various ages ranging from early Aptian to middle Cenomanian. However, the lower members of this group (Lakota Sandstone and Fuson Shale of Darton, 1905) were assigned to ages earlier than late Albian, and the restricted Dakota Sandstone Formation was considered by these workers to range from late Albian through middle Cenomanian.

Berry (1920) was opposed to the determination of Twenhofel (1920) that the Dakota Sandstone Formation was of Lower Cretaceous age. In this paper Berry cited floristic evidence

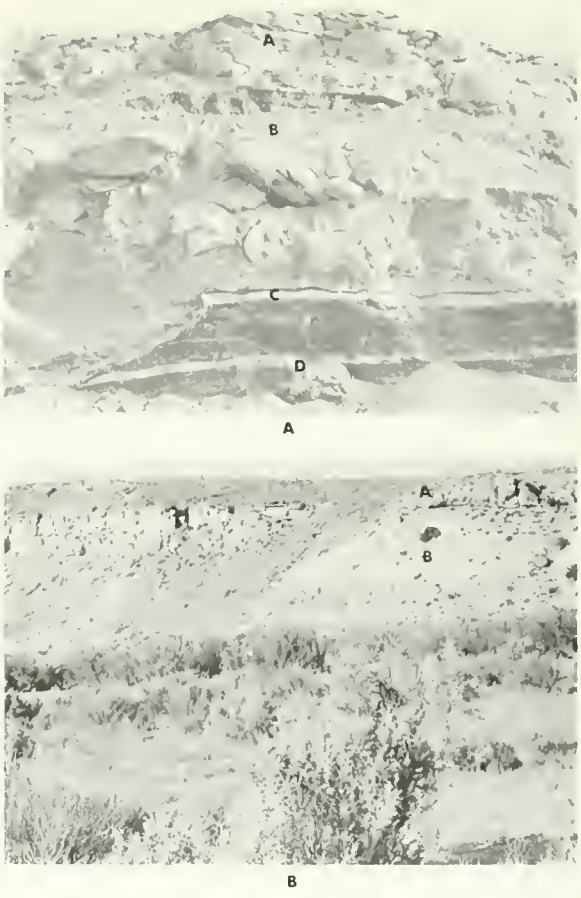

FIG. 4. A. Roadcut exposure of Dakota Sandstone Formation. The upper massive sandstone unit (A) of this formation from this region rests upon the middle shale-coal-sand unit (B). C delimits an unfossiliferous ash, and D represents the chief fossiliferous ash seam. B. Contact between Dakota Sandstone and Cedar Mountain-Morrison Formation. The Dakota forms the slope and ledge (A) which rests upon the slope of the Cedar Mountain-Morrison Formation (B).

that the Dakota was of Upper Cretaceous (Cenomanian) age and could be correlated with the Woodbine Formation of Texas. However, Berry (1922) later considered the Woodbine Formation to be of Turonian age, although still to be correlated with the Dakota Sandstone Formation. This determination was based upon a detailed analysis of the flora of the Woodbine Formation from Lamar County, Texas, wherein it was noted by Berry that this flora had three species in common with Turonian floras of Europe.

MacNeal (1956) restudied the Woodbine flora from collections made in Denton County, Texas. Based upon examination of more and better material, MacNeal disagreed with the age determination of Berry, and assigned the

Woodbine flora to a Cenomanian age. MacNeal did, however, agree with Berry (1920) that the Woodbine flora is closely related to the flora of the Dakota Sandstone.

A Cenomanian age for the Woodbine was also agreed upon by Stephenson (1952) based upon a study of the invertibrate fauna from this formation.

Brown (1952) agreed with Berry (1920) that the Woodbine flora is very similar to the flora of the Dakota Sandstone of Kansas. One apparent difference, however, was the conspicuous absence of gymnospermous species in the Woodbine flora. This difference was eliminated by MacNeal (1958) in his Woodbine studies and recently by Hedlund (1966) in his palynological studies on the Red Branch Member of the Woodbine.

Hedlund (1966) also confirmed the Cenomanian age of the Woodbine Formation. In this paper, Hedlund treated many species of fern and gymnosperm palynomorphs indicating that this segment of the flora, even though poorly represented by macrofossils, nonetheless, represents an important floristic component of the Woodbine.

Pierce (1961), Hall (1963), and Agasie (1967) in reporting on microfloral assemblages from the Dakota Sandstone Formation of Minnesota, Iowa, and Arizona, respectively, assigned this formation to a Cenomanian age. The present author agrees with this Cenomanian assignment of the Dakota Sandstone Formation, although in part this formation may be of late Albian age (Cobban and Reeside, 1952).

A CONCEPT OF A DAKOTA FLORA

It was recognized from earlier plant collections from the Dakota Sandstone Formation that plants from this formation were rather closely related to plants growing on the earth at the present time. Fossils from these collections were representatives of dicotyledonous families and genera most of which are still represented in the earth's flora. As Meek and Hayden (1859) commented, Dakota fossils "belong to a higher and more modern type of dicotyledonous trees. . . ."

As more collections were made from this formation throughout the midwestern United States from such diverse localities as Kansas, Nebraska, North Dakota, South Dakota, Wyoming, New Mexico, etc., a floristic picture of the Dakota began to evolve. This picture was essentially that of Meek and Hayden (1859), and later of Lesquereux (1874, 1883), that the flora of the Dakota was essentally a modern type of flora without many fossils representing antecedent floristic types. As mentioned by Lesquereux (1874) only one specimen collected to that time could be referred to the Cycadophyta (*Pterophyllum* (?) *haydenii*), and even this reference was doubtful. Conifers were rare from these early studies, both in number of species and number of specimens, and represented a very limited portion of the flora. Likewise, ferns were few in number and appeared to make up a very limited part of the total Dakota vegetation.

On the other hand, even from earliest studies, it was apparent that plant fossils referable to the modern angiospermous vegetational type were exceedingly common and comprised by far the dominant part of Dakota vegetation. Indeed, Lesquereux (1874) noted that dicot species represented in the Dakota floras could be referred to "genera to which belong most of the living arborescent plants of this country (North America) and of our present climate."

When these facts were considered by Lesquereux (1874), he wrote a section dealing with the disconnection of Dakota floras with antecedent types. In this chapter, Lesquereux wrote:

> . . . it is evident that the flora of the Dakota Group is as widely disconnected from that of the Jurassic, even of the Lower Cretaceous, or as distinctly original, as are the flora of the Carboniferous compared to that of the Devonian, or the Permian types compared to those of the Cretaceous.

Later studies (Lesquereux, 1883, 1892) indicated that although ferns and gymnosperms were more common than indicated by earliest studies, these floral types were still present in limited numbers. Thus, Lesquereux (1892) in his final work on the flora of the Dakota Group summarized the relative importance of the different components of this flora. Of a total of 460 species identified from the Dakota Sandstone flora, Lesquereux recognized six species of ferns, representing 1.3 percent of the total flora; twelve cycadean species representing 2.6 percent; fifteen species of conifers representing 3.5 percent; and 437 species of angiosperms representing 92.6 percent of the total flora.

In the light of the above discussion, it may be summarized that the prevailing early concept of the flora of the Dakota Sandstone Formation was that it was essentially a modern flora composed principally of dicotyledonous leaves related to modern arborescent genera. The apparent paucity of antecedent floral types (Jurassic-Wealden ferns and gymnosperms) common in earlier Mesozoic floras is noteworthy, although somewhat enigmatic to some early paleobotanists. It must be remembered, however, that this concept grew out of studies by Lesquereux and others of macrofossils from the midwestern portion of North America and was drawn without the aid of data from two sources to be added later. These two sources are microfloral analysis of the Dakota, and megafloral analysis of this formation from many new localities, especially those further west than original collection sites.

As more data accumulate concerning the Dakota Sandstone Formation, particularly data dealing with regions west of the Rocky Mountains, it becomes clear that a valid concept of a Dakota flora must be modified somewhat from early views. While this early concept is essentially for megafloral assemblages from that portion of this formation east of the Rocky Mountains, it does not fit well for the formation as a whole. In this respect, it is significant that the incidence of species representative of the antecedent Jurassic-Wealden vegetational type, particularly Middle Mesozoic ferns, is much higher in megafloral assemblages from several localities in the Dakota Sandstone Formation west of the Rocky Mountains. That is not to say that dicotyledonous species are not present at these localities. They are not only present, but they are directly related to the dicotyledonous species from this formation further to the east. Indeed, at some of these collection sites, angiospermous fossils comprise the dominant floristic component of the fossil assemblage. However, from many localities in the Dakota Sandstone Formation in Utah, Colorado, and Arizona, fossils representative of the older antecedent vegetational type are relatively more important than their counterparts east of the Rockies, both in number of species and number of specimens present. Indeed, at some western localtities, representatives of this ancient floral type dominate the floral assemblage.

The Dakota flora from Montrose County, Colorado, represents an admixture of representatives of the Jurassic-Wealden vegetational type with modern angiospermous forms. Early work by Cockerell (1916) and Berry (1919a) indicate the presence of matoniaceous ferns from this region. Ferns referable to this family are representative of an earlier floral type, as they are common in the European Wealden and other Middle Mesozoic strata. Matoniaceous ferns are uncommon from rocks younger than Early Cenomanian, and are unknown from Tertiary strata. Brown (1950) made further studies on the plants from several localities in the Dakota of Montrose County. This author also treated matoniaceous ferns, as well as ferns of the family Gleicheniaceae, which are also indicative of a preangiospermous floral type. Several other ferns from the Dakota of this region were also discussed by Brown. The author has had occasion to study the Dakota collections from Montrose County reported by Brown. It is apparent that the fern families Matoniaceae and Gleicheniaceae were very well developed in this region during Dakota times. Indeed, ferns of these two families are so common that they make up the predominant part of the fossil vegetation, although they are collected in association with angiospermous forms which, as mentioned by Brown (1950),

> . . . include chiefly species that occur in the large flora described by Lesquereux, Newberry and others from the brownish Dakota Sandstone of Kansas and Nebraska, in the Woodbine Formation of Texas, the Dakota of the Black Hills, South Dakota, and the Upper Cretaceous rocks of Greenland.

Therefore, during Dakota times in southwestern Colorado, the vegetation was composed of typical Dakota angiospermous species, but with a large proportion of plants representative of a more ancient floristic type.

A somewhat similar situation existed in Grand County, Utah, during Dakota times. Similar to the fossils from Colaroda, the Dakota flora from this part of Utah is comparable to Dakota floras from other localities. However, it is both significant and apparent that the flora from the Grand County Dakota Sandstone Formation is very much dominated by ferns representative of the older Jurassic-Wealden vegetational type. Indeed, it is almost impossible at some localities in Grand County to crack open a rock without exposing at least one specimen of a fern representative of the families Matoniaceae or Gleicheniaceae. Dicotyledonous species are reduced both in number of species and number of specimens present. Gymnosperms represent a rather minor part of the flora from this region as far as number of species present, although quantitatively they are represented by large amounts

of silicified wood. Therefore, the Grand County Dakota flora may be characterized as a fern-dominated, fern-angiosperm-gymnosperm alliance, similar to what could be expected during a time which directly preceded the much discussed "population explosion" of angiosperms during Cenomanian times (Seward, 1927).

This same vegetational aspect has been observed by the author from several other Dakota localities of the western United States. Floras from Longhouse Valley and Kayenta, Navajo County, Arizona, both exhibit characteristics discussed above in connection with Colorado and Utah Dakota floras. That is, ferns representative of the old Jurassic-Wealden vegetational type dominated the Dakota vegetation of these regions, and angiosperms represented a rather limited vegetational type.

The Dakota Sandstone Formation from Coal Canyon, Coconio County, Arizona, as discussed by Agasie (1967) exhibits similar floristic characteristics. Microfloral analysis from this region indicates that Dakota vegetation was composed of a fern-angiosperm alliance with a minor gymnospermous component. Fern spores represent the dominant microfloral component, especially forms related to the famly Schizaceae. This fern family is often represented in pre-angiospermous floras (Harris, 1961), and preliminary collection of megafossils from the area also indicates the presence of many ferns related to an old Jurassic-Wealden vegetational type.

In addition to the data presented above, it has been shown by Pierce (1961) and Hall (1963) from microfloral analysis of two localities in the Dakota from Minnesota and Iowa respectively, that ferns and gymnosperms represented more important components of the eastern Dakota flora than indicated by the megafossil record. With respect to this, Pierce reported 24 species of palynomorphs representative of angiospermous species, 36 species of gymnospermous palynomorphs, and approximately 20 species of fern palynomorphs. Based on this, Pierce postulated that angiospermous species are not as important in this formation as indicated by the megafossil record. However, a more precise conclusion would be that rather than the angiosperms representing a less important floral component, the gymnosperm-fern floral component represents a more important part of the flora than previously thought.

From the above discussion, a more accurate concept of the flora of the Dakota Sandstone Formation as a unit may be formed. In western America, the Dakota flora is a fern-angiosperm alliance with a relatively small gymnospermous component. At several localties west of the Rockies, ferns dominate the megaflora as well as the microflora. To the east, this flora changes character somewhat, becoming an angiosperm-dominated flora with a fern and gymnosperm component. This fern-gymnosperm component was originally thought to be of very minor importance in the eastern Dakota, but recent microfloral studies (Pierce, 1961) have demonstrated that this component of Dakota vegetation was more important than had been previously supposed.

PALEOECOLOGY

The plants from the Dakota Sandstone Formation near Westwater are preserved in a light tan ash layer from five to ten inches in thickness. This layer was deposited directly upon a coal seam and is overlain by another. These plants are extremely well preserved with many of the leaf compressions illustrating cuticle, vascular tissue, and reproductive structures. In addition, many of these fossils are disposed in the strata in such a manner as to indicate that the plants were preserved in growth position, suggesting that deposition of the ash was rapid.

The ash layer is uniform in color and composition throughout, with the exception of a one- to two-inch portion directly beneath the upper coal seam. Laterally throughout the ash, distribution of the plants is differentential. Thus, within a local area, most of the plants are of the same species, and laterally the species change abruptly within a distance of a very few feet. In certain outeroppings of the ash, dense mats of leaves are found within a relatively small area. These mats are normally found in the lower portion of the ash, and if one traces them laterally, they appear to follow definite channels indicating possible stream channels.

Peels of the foliage of the channel areas were prepared to aid in identifying the angiosperms. On one of these peels a well-preserved diatom and several spores of either algal or fungal origin were found, indicating the likelihood that the depositional environment of matted leaves in these areas was aquatic.

More detailed study of the fossiliferous ash brought to light several other important factors.

In all areas near Westwater where the plant-bearing ash has been examined, the contact between the ash and the underlying coal seam is very sharp and easily distinguished (Fig. 5). In addition, the lowermost portion of the ash contains large numbers of root and rhizoid-like structures, often in such profusion as to form dense mats of these structures (Fig. 6). Leaves are scarce in the lower portion of the ash with the exception of poorly preserved, often broken specimens. One of the more important identifiable fossils common in this region of approximately one inch in thickness is the rhizome of *Equisetum lyelli* Mantel with attached tubers.

Immediately above this rhizome region is a horizon containing numerous well-preserved leaf impressions. This region contains foliage belonging almost exclusively to the three fern genera *Matonidium*, *Astralopteris*, and *Gleichenia*. This zone is approximately five to eight inches thick and is literally full of beautifully preserved specimens.

At the upper portion of this dense foliage region, the color and composition of the ash changes somewhat (Fig. 5). The ash becomes noticeably darker in color and somewhat silty-carbonaceous in composition. Many of the fossils found in this region differ taxonomically from those found lower in the ash. While the three genera *Matonidium*, *Astralopteris* and *Gleichenia* are still present as leaf impressions in this region, they are not as dominant as they were in the lower portions of the ash.

Plant fossils in this upper region represent several different genera. The greatest taxonomic diversity in the Westwater flora occurs within this zone. Significantly, *Equisetum* rhizomes reoccur in this upper region after being noticeably rare in collections from the middle portion of the ash.

The contact between the ash and the upper coal seam is not as sharp as the lower contact (Fig. 5). From the point where the ash becomes carbonaceous in nature and diversity in the flora appears, the ash layer gradually becomes more carbonaceous until within a distance of one to two inches it grades into a well-defined lignitic coal.

Several explanations for the above described phenomena have been considered and rejected. The sharp contact between the lower coal and ash indicates that the ash fell directly upon a coal swamp and preserved the plants that were growing at the time. Further evidence in support of this is noted when it is recalled that at the base of the ash a region rich in rootlike

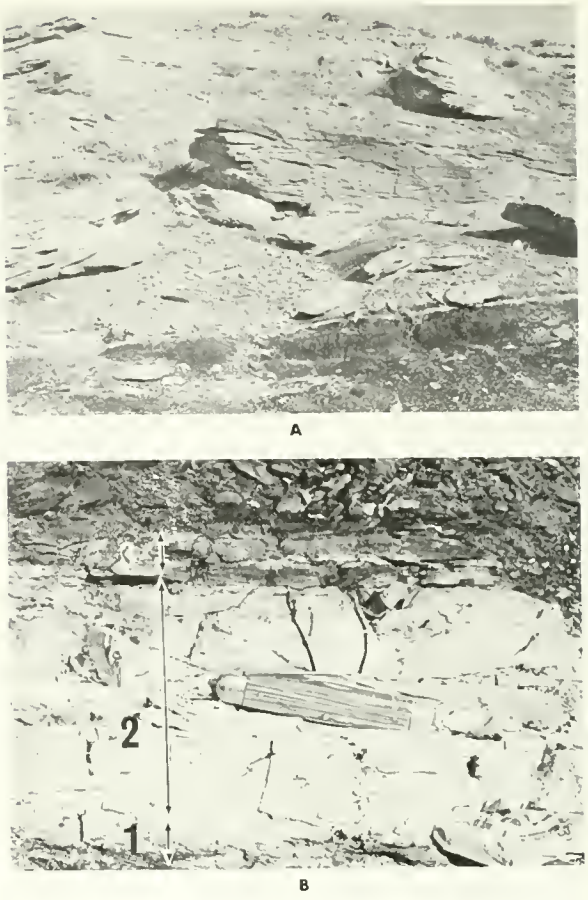

FIG. 5. A. Collecting site exhibiting characteristic lithology of Dakota Sandstone near Westwater. The upper massive sandstone unit forms the cliff, and the weathered shale-coal-sand sequence forms the talus slope in the foreground. B. Close-up of fossiliferous ash seam illustrating rhizome region (1), leaf region (2), and diversity region (3).

structures, rhizomes, partially decomposed leaves, stream channels, etc., occurs. Above this is a region extremely rich in matoniaceous, gleicheniaceous, and astralopteroid fossils which appear to be in growth position. This evidence would tend to support the hypothesis that the ash was deposited rapidly upon a coal swamp which was composed chiefly of ferns of the three genera *Matonidium*, *Gleichenia* and *Astralopteris*. If this indeed occurred, the rhizome region would contain mostly rhizomes and roots of these three genera.

The upper portion of the ash where the diversity appears contains plants which may represent forms that began to grow upon the previously deposited ash. That is, the plants of the upper part of the ash represent forms that repopulated the swamp following ash deposition. The likely reason for the diversity in taxonomy of these plants is that they are forms

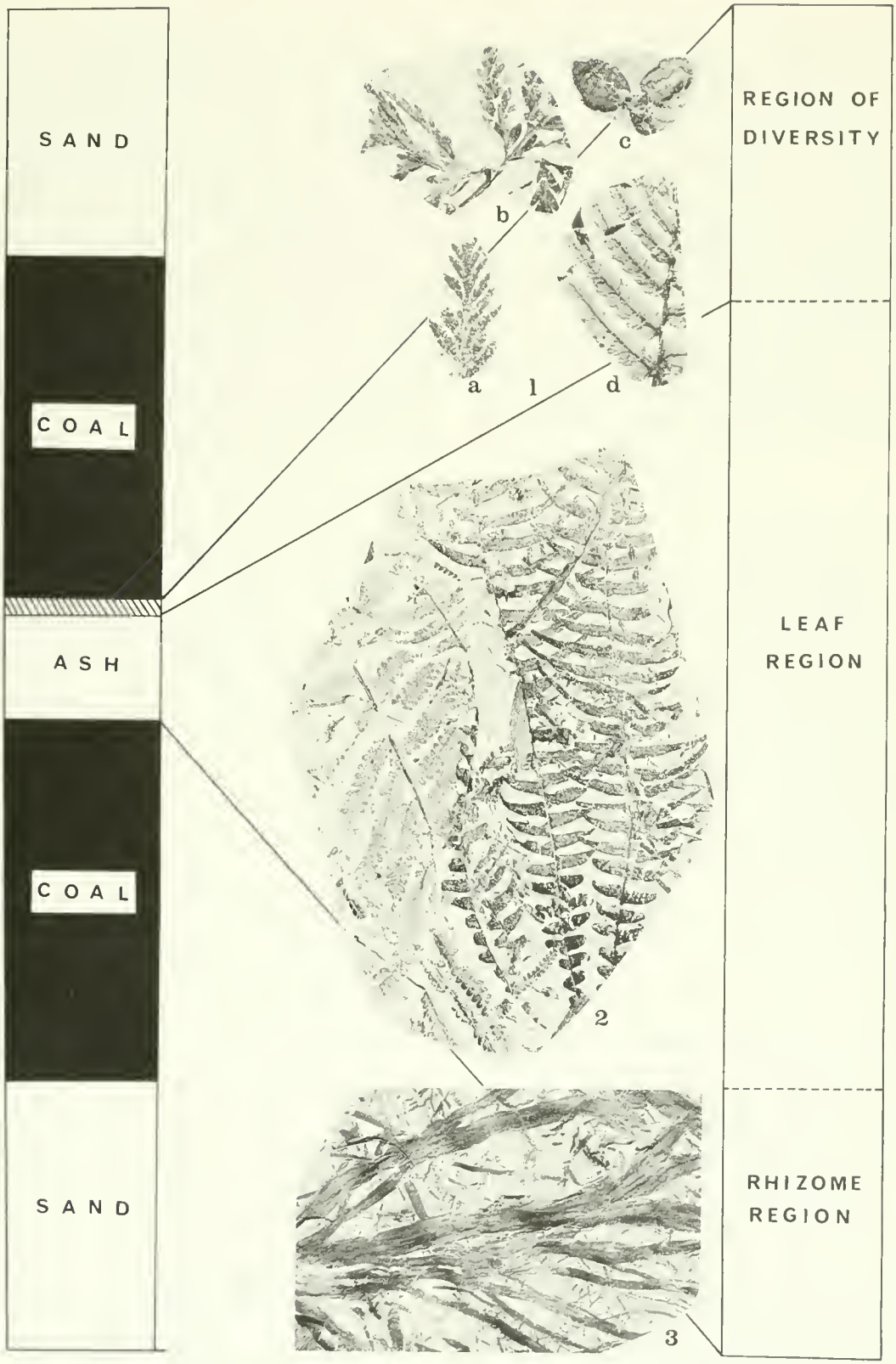

Fig. 6. 1. Representative forms found in region of diversity: *Coniopteris* (a); *Asplenium* (b); *Equisetum* (c); and *Cladophlebis* (d). 2. Single specimen collected from leaf region illustrating *Gleichenia* and *Matonidium*. 3. Rhizome and rootlike structures collected from rhizome region.

from seral communities in secondary succession. It is likely that the climax vegetation growing in the coal swamp was a *Matonidium-Gleichenia-Astralopteris* association. Further evidence in support of this conclusion was obtained by the author from study of mascerations of the lower and upper coals. Even though palynomorphs from these coals were poorly preserved, it was evident that matoniaceous fern spores were the dominant microfossils from both, indicating that species of *Matonidium* were prevalent both prior to and subsequent to ash deposition.

To test the above hypothesis, thin sections of the ash were made from the three discussed regions (rhizome region, leaf region, and diversity region). The ash of the rhizome and leaf regions shows no difference when examined microscopically. However, the ash of the region of diversity is much more silty and carbonaceous than the ash of the two lower regions. This evidence would tend to support the theory that the plants of the rhizome and leaf regions were preserved in one ash fall. The silty carbonaceous region (region of diversity) represents a region of increased silt and carbon deposition due to the initial deposition of enough soil to support plant growth, population of this soil by new plants (secondary succession), and subsequent carbon deposition as these plants died and were deposited. These plants probably represent stages in seral succession toward the climax coal swamp vegetation of *Matonidium*, *Gleichenia* and *Astralopteris*.

PALEOCLIMATE

It is sometimes possible, particularly when working with late Mesozoic and Tertiary paleofloras, to reconstruct the presumed climate under which these fossil floras existed. Two basic methods used in determination of paleoclimates are the comparison of fossil genera to their nearest living relatives existing under known climatic conditions (extrapolation through uniformitarianism), and the determination of dicotyledonous leaf characteristics and comparison of these characteristics with those found in species growing in known climatic conditions.

It was first recognized by Bailey and Sinnott (1915) that leaves of arborescent dicotyledonous species growing in tropical regions exhibit a higher incidence of entire margins than do their counterparts growing under nontropical conditions. These authors pointed out that there is a correlation between the number of entire margins of arborescent dicot species to climatic conditions under which these species exist. Thus, from seventy to ninety percent of tropical woody dicot species exhibit entire leaf margins, whereas only twenty to forty percent of woody dicots of cold temperature regions exhibit entire margins. Further studies (Sinnott and Bailey, 1915; Chaney and Sanborn, 1933) pointed out that large leaves, thick leaves, compound leaves, and leaves with attenuated apices are more abundant in tropical regions, decreasing proportionately into temperate regions.

Chaney (1954) applied these characteristics in analyzing 200 species of leaves from the Dakota flora in an effort to determine the paleoclimate of Dakota times. He noted that 73 percent of the leaves from this flora exhibit entire margins, 44 percent are over 10 cm long, and 74 percent are thick in texture. From these data, Chaney concluded that the Dakota flora lived under conditions "more subtropical than temperate." Chaney further pointed out that 72 percent of Dakota leaves exhibit camptodrome venation patterns which, according to Chaney, also indicates that the climate during Dakota times was tropical or subtropical in nature. Chaney suggested that this angiosperm flora existed in a lowland forest, and that some highland regions were to be found nearby.

Pierce (1961) discussed the Cretaceous climate of Minnesota based upon a fossil pollen assemblage from this region. He concluded that the flora could be characterized as a coniferous rain forest growing under warm temperate climatic conditions similar to conditions found presently in the Pacific Northwest of the United States or the coastal regions of eastern Asia. This was based upon an unusually high frequency of gymnospermous pollen encountered which, Pierce argued, could not have come from nearby upland regions. Based upon this information, Pierce agreed with Lesquereux (1874) who suggested that the Dakota flora was similar to the modern flora growing between 30° and 45° north latitude. However, Lesquereux never assumed that the Dakota flora was a coniferous forest, or that it even contained a large number of gymnosperms. Indeed, just the opposite was the case as Lesquereux (1874) discussed the noteworthy absence of gymnospermous and fern species from the Dakota flora. The work of Pierce, however, does point out that both the gymnospermous and the fern

component of the Dakota flora are larger than indicated by megafloral analysis.

Hedlund (1966), in considering the pollen flora from the Red Branch Member of the Woodbine Formation which is closely related to the flora from the Dakota Sandstone, compared component members with their modern counterparts and concluded that the climate of this region during Woodbine times was warm temperate to tropical. His determination was based upon the high incidence of palynomorphs related to modern plants which are presently distributed chiefly in warm temperate-subtropical regions.

A Dakota pollen flora from Coal Canyon, Arizona, indicates subtropical to tropical climatic conditions for this region during Dakota times (Agasie, 1967). This is based upon relatively high frequency of palynomorphs from genera related to extant taxa growing under wet tropical or subtropical conditions. The relatively high frequency of gymnospermous pollen present in this flora indicates that well-drained, low upland regions existed near the lowland swampy depositional basins.

Several species and hundreds of specimens of *Matonidium* are present in the Westwater flora. These ferns are probably the best climatic indicators present in this flora. These fossils are related to the fern family Matoniaceae which is presently a monotypic (Bower, 1923) or ditypic (Holtman, 1947) family containing the genus *Matonio*. This genus is extremely limited geographically and climatically in the present world's flora and grows only in the humid tropical upland regions of the Malayan Peninsula. As mentioned by Mahabale (1954) matoniaceous ferns are among a select group of ferns that are accurate climatic indicators.

Gleicheniaceous ferns are well represented in the Westwater flora, although these fossils are somewhat less valuable than matoniaceous ferns as climatic indicators. Of 80 extant species the majority are of tropical distribution, although some species extend well into southerly latitudes (Bower, 1923).

The fern family Dipteridaceae is also represented in the Grand County flora. This family is monotypic containing the genus *Dipteris*, which is presently restricted to five species all of which are found in the Indio-Malayan region of the world (Bower, 1923). Thus, this family also may be cited as an excellent example of a tropical or subtropical climatic indicator.

In addition to the above evidence, most observed angiospermous fossils exhibit entire leaf margins and two species show long attenuated apices (drip points) which are thought to function in facilitating the run off of excess moisture. As mentioned previously, these characteristics are found more frequently in tropical regions, and thus, the Dakota angiosperms from Westwater substantiate the conclusion that the Westwater Dakota flora grew under subtropical to tropical conditions.

Topography at the time of deposition of the shale-coal-sand unit of the Dakota Sandstone Formation of this region was likely a broad swampy mudflat near the shore of the Cenomanian Sea. Pockets of dense vegetation composed basically of ferns and *Equisetum* developed in some of these regions, often accumulating enough volume, under proper conditions, to comprise a large component of the coal deposits which occurred between sandy or shale sequences. Well-drained highland areas existed nearby with gymnosperms and angiosperms present. Streams ran from the upland regions into the lowland swampy areas carrying leaves and other debris in various stages of decomposition. The vegetative deposits from these streams (gymnosperm and angiosperm leaves, and likely wood) probably formed a large portion of the coals, with the remainder being added from the ferns and associated plants of the fern swamps.

Following a period of time when deposition occurred as outlined above, the shoreline of the sea changed, and the shale-coal-sand sequence in the Dakota of the Westwater region was overlan by a massive sand sequence. Following this, the entire formation was overlain by deposits from the Mancos Sea.

SYSTEMATICS

Division ARTHROPHYTA

Genus EQUISETUM L.

Harris (1961) discussed the usage of *Equisetum* and *Equisetites* for fossils exhibiting similarities to the extant *Equisetum*. Harris elected to use *Equisetum* since "No morphological difference has ever been proved between *Equisetum and Equisetites*. . . ." This statement is completely accurate, and furthermore, the fossil and living forms exhibit striking morphological similarity. In view of this, the author

has followed Harris (1961) and others in using *Equisetum* for placement of fossils which exhibit characteristics similar to those of the extant genus.

Equisetum lyelli Mantel

Figs. 7-3, 7-5; 15-5, 15-9.

1889 *Equisetum marylandicum* Fontaine—U.S. Geol. Surv. Mon. 15, p. 65, Pl. 170, Fig. 8.

1893 *Equisetum lyelli* Mantel, Dawson—Trans. Roy. Soc. Can. v. 10, pt. 4, p. 83, text-Fig. 1.

1956 *Equisetites lyelli* (Mantel) Unger, Bell—Geol. Surv. Can. Mem. 285, p. 76. Pl. 28, Figs. 5-8.

DESCRIPTION.—Rhizome horizontal, unbranched, 2-4 mm in diameter, smooth to slightly ribbed, bearing short tuber-bearing branches at intervals as close as 8 mm; tubers ovoid to globose, commonly wrinkled, subtended by leaflike bracts, 13 mm long by 6 mm wide, borne in pairs; upright stems unknown.

OCCURRENCE.—Dakota Sandstone Formation near Westwater, Grand County, Utah.

REPOSITORY.—Brigham Young University, BYU 1807-1810.

DISCUSSION.—Many specimens of *Equisetum* have been collected from the Westwater flora. These specimens may be easily identified by their attached tubers, although positively identified stem material is absent. Specimens obtained from this flora are collected for the most part from the lowermost and uppermost portions of the ash.

It is rather difficult to assign this plant to any known species since no aerial stems have been observed. However, rhizomes of *Equisetum* are not uncommon in the fossil record, and the Westwater material rather closely resembles some described specimens.

Fontaine (1889) described *Equisetum virginicum* based upon both aerial stem and rhizome material. The aerial stem was highly branched, and tubers (called imperfect buds by Fontaine) were borne individually along the rhizome. This specific name was used again later by Fontaine (1899) for placement of a specimen from the Black Hills Lower Cretaceous. Bell (1956) noted that in overall morphology, *E. virginicum* is very similar to *E. lyelli* Mantel.

Equisetum marylandicum was described in 1889 by Fontaine. The aerial stem of this species was highly branched, although a rhizome questionably attributed to this species (op. cit., Pl. 179, Fig. 8) is very much similar to rhizomes collected from Westwater.

Bell (1956) illustrated tuber-bearing rhizomes of *Equisetites lyelli* (Mantel) Unger (*Equisetum lyelli* Mantel). These rhizomes differ from the Westwater specimens by being branched and exhibiting strongly ribbed internodes. Other differences are the whorled disposition of tubers and the apparent lack of bracts subtending tubers on the Canadian specimens. However, the dimensions of the Canadian material compare well with those noted for Westwater specimens, although the tubers are commonly somewhat larger in the latter.

Other citations of *E. lyelli* are incomparable to the Utah specimens since only aerial stems are described. Thus, Schenk (1871) described aerial stems of *E. lyelli* as being much branched, and with larger dimensions than would be expected for aerial stems of the Westwater *Equisetum*, and Fontaine (1889) noted that characteristics of aerial stems of *E. lyelli* from Virginia agreed closely with those of this species from Europe as noted by Schenk (1871).

Division FILICOPHYTA

Genus ASPLENIUM L.

This genus is rather large and is well represented both in the modern and fossil flora. Bower (1923) reported *Asplenium* to contain 429 extant species, and Jongmans (1957) listed 96 fossil species of this genus with three varieties and listed ten as *Asplenium* sp. In addition, *Asplenites* has been used for placement of asplenioid ferns resembling the modern *Asplenium*; this genus contains several additional species.

Most of the fossil species of *Asplenium* are based upon sterile foliage, and undoubtedly many are synonyms. This problem is further complicated by the fact that sterile foliage of this genus rather closely resembles foliage of several other fern genera such as *Anemia*, *Onychiopsis*, *Sphenopteris*, *Acrostichopteris*, *Coniopteris*, and *Dicksonia*. There is no adequate way of determining between some species of these genera and between species of *Asplenium*, based upon sterile foliage alone. Clarification of resulting taxonomic problems awaits further collection and study of existing specimens.

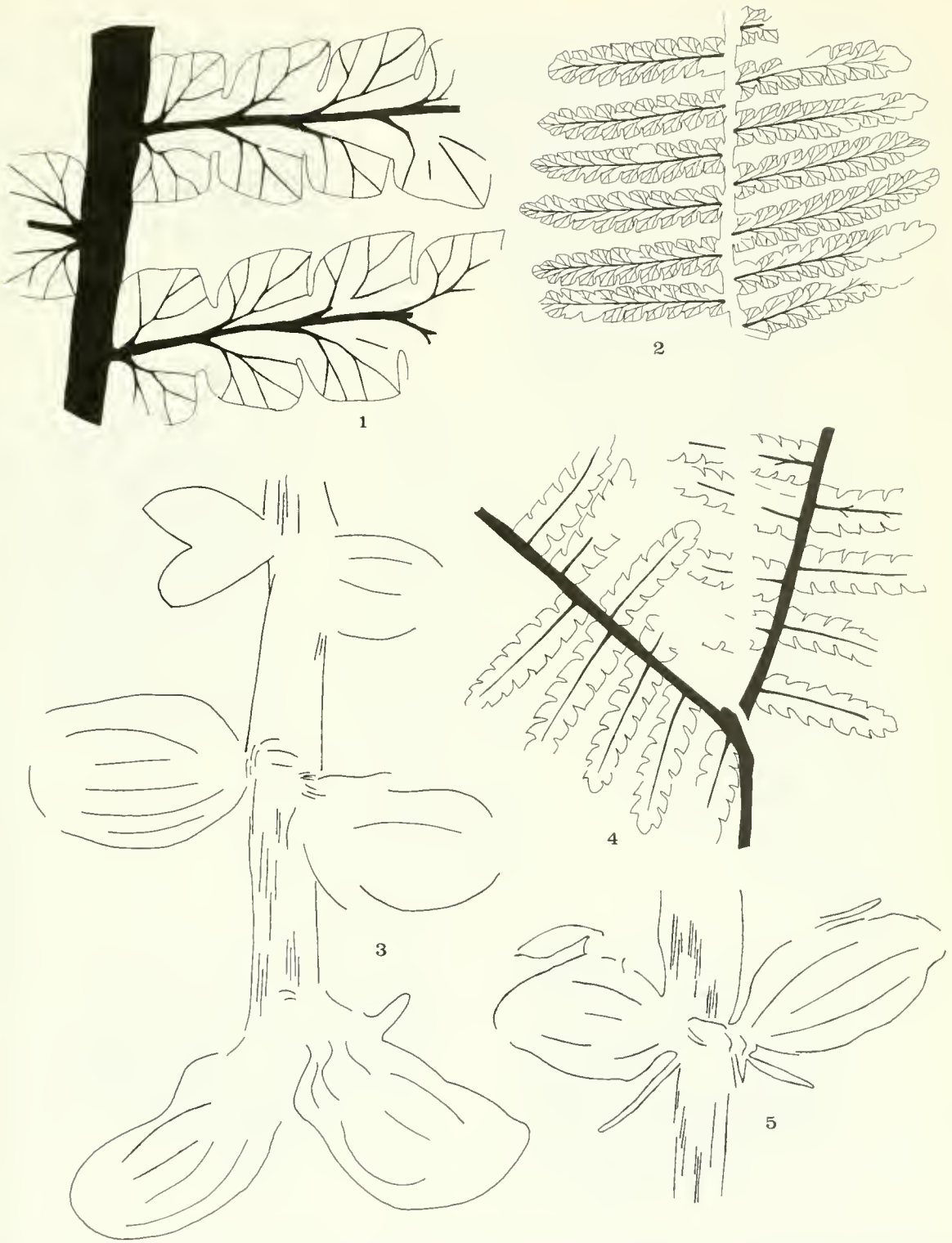

Fig. 7. 1. *Gleichenia delicatula* Heer. Portions of pinnae illustrating pinnule shape and disposition. (X12:5). BYU 1829. 2. *Gleinchenia delicatula* Heer. Portions of pinnae illustrating pinnule shape and disposition. (X3). BYU 1829. 3. *Equisetum lyelli* Mantel. Portion of rhizome illustrating shape and disposition of tubers. (X3). BYU 1809. 4. *Gleichenia delicatula* Heer. Pinna fragment illustrating characteristic branching. (X3). BYU 1830. 5. *Equisetum lyelli* Mantel. Portion of rhizome illustrating tubers with subtending bracts. (X3). BYU 1810.

Asplenium dicksonianum Heer

Figs. 8-4; 11-3; 12-2; 15-4.

1874 *Asplenium dicksonianum* Heer—Flor. Foss. Arct., v. 3, pt. 2, p. 31, Pl. 1, Figs. 1 (excl. b, c), 1aa, 2-4, 5 (excl. a, b).

1899 *Asplenium dicksonianum* Heer, Ward—U.S. Geol. Surv. 19th Ann. Rept., pt. 2, p. 704, Pl. 170, Fig. 1.

1950 *Asplenium* sp. Brown—U.S. Geol. Surv. Prof. Paper 221-D, p. 48, Pl. 10, Fig. 4.

DESCRIPTION.—Entire leaf unknown, at least bipinnate; ultimate pinnae alternate, up to 90 mm or more long by 50 mm wide; pinnules lanceolate, entire to deeply cut, alternate, up to 40 mm long by 9 mm wide; attachment basal to single point; midvein strong at point of origin, not extending to pinnule apex, dividing; secondary veins repeatedly divided, free throughout; fertile specimens unknown.

OCCURRENCE.—Known from the Dakota Sandstone Formation near Hot Springs, South Dakota, near Naturita, Montrose County, Colorado, and near Westwater, Grand County, Utah.

REPOSITORY.—Brigham Young University, BYU 1811-1814.

DISCUSSION.—The author has elected to follow Ward (1899) who collected an asplenioid fern from the Dakota Sandstone of the Black Hills region and placed it in *A. dicksonianum*. However, Brown (1950), in describing a similar fern collected by Stokes from the Dakota Sandstone of Montrose County, Colorado, noted that both the Colorado and the South Dakota specimens appeared to be somewhat smaller and more delicate than typical specimens of *A. dicksonianum*. However, based upon material in his possession, Brown (1950) was hesitant to name a new species of this genus and so ascribed the material to *Asplenium* sp.

The observations of Brown were accurate for some specimens of *Asplenium* from Colorado. However, with the smaller forms mentioned by Brown (1950) are many which are larger and resemble rather closely *A. dicksonianum*. Westwater specimens of *Asplenium* are also like *A. dicksonianum*, although positive identity of this fern awaits collection of specimens illustrating soral and sporangial characteristics.

Asplenium dakotensis Rushforth, sp. nov.

Figs. 11-5, 12-6.

DESCRIPTION.—Entire leaf unknown, bipinnate; petiole smooth, 1-2 mm in diameter, bifurcating to give rise to two rachi; pinnae alternate, 35 mm or more long by 11 mm wide; lance olate; pinnules ovoid, up to 9 mm long by 3.5 mm wide, alternate, attachment basal with rounded sinuses, to nearly single point, apices obtuse to rounded, margins entire; midvein strong at point of origin, not extending to pinnule apex, dividing; secondary veins mostly obscure, free, extending to pinnule margin; fertile specimens unknown.

OCCURRENCE.—Known from the Dakota Sandstone Formation near Westwater, Grand County, Utah.

REPOSITORY.—Brigham Young University, holotype; BYU 1806.

DISCUSSION.—*Asplenium dakotensis* is proposed for a small, rather delicate *Asplenium* from the Westwater flora. It differs from *A. dicksonianum* Heer from the same locality by being much smaller, both in pinnule and pinna size, and by pinnules being entire and rather strap-shaped, rather than dentate or deeply cut and lanceolate as are pinnules of *A. dicksonianum* (Table 1). *A. dakotensis* Rushforth is also much smaller than most other species of *Asplenium* and differs from many by having pinnules with entire margins. It is also rather unique in its bifurcated petiole which gives rise to two rachi. This last characteristic coupled with pinnule shape and margination led the author to consider this fern closely related to *Knowltonella* Berry (1911). However, examination of the type specimens of *Knowltonella* indicates that the branching habit of the two differs, as does pinnule shape. Fertile specimens of neither *Knowltonella* nor *A. dakotensis* have been discovered, and for the present, the author prefers to assign this fern to the Aspleniaceae as *Asplenium dakotensis*, rather than to the Matoniaceae under *Knowltonella*.

Table 1

Comparative Morphology of *Asplenium dicksonianum* Heer and *Asplenium dakotensis* Rushforth

	A. dicksonianum	*A. dakotensis*
Length of pinna	90 mm	35 mm
Width of pinna	50 mm	11 mm
Length of Pinnule	40 mm	9 mm
Width of Pinnule	9 mm	3.5 mm
Pinnule shape	Lanceolate	Strap-shaped
Pinnule margin	Entire to deeply cut	Entire

Fig. 8. 1. *Gleichenia delicatula* Heer. Pinna fragment illustrating characteristic branching. (X1.2). BYU 1827. 2. *Matonidium brownii* var. *magnipinnulum* Rushforth. Pinna fragment illustrating long, linear pinnules. (X1.2). Holotype: 1566. 3. *Gleichenia delicatula* Heer. Pinna fragment illustrating pinna and pinnule disposition. (X1.2). BYU 1828. 4. *Asplenium dicksonianum* Heer. Pinna illustrating ultimate pinnae disposition. (X1.2). BYU 1811. 5. *Cladophlebis parva* Fontaine em. Berry. Pinna fragment illustrating pinnule disposition. (X1.2). BYU 1842. 6. *Gleichenia comptoniaefolia* (Deb. and Ett.) Heer. Pinna fragment illustrating characteristic branching. (X1.2). BYU 1817. 7. *Asplenium dicksonianum* Heer. Pinna fragment illustrating disposition of ultimate pinnae. (X1.2). BYU 1812.

Family DICKSONIACEAE

Genus CONIOPTERIS Brongniart

Coniopteris is probably the best known fossil genus of the fern family Dicksoniaceae. As listed by Jongmans (1959) this genus contains approximately 45 species and three varieties. However, as discussed by Harris (1961) this genus is in need of revision, and fewer than 45 species are likely to be valid.

Coniopteris westwaterensis Rushforth, sp. nov.

Figs. 10-2; 11-4; 13-5.

DESCRIPTION.—Entire leaf unknown, at least bipinnate, some divided into a sterile portion below and fertile portion above; sterile pinnae lanceolate, up to 20 mm wide by greater than 60 mm long; pinnules subopposite to alternate, up to 12 mm long by 3 mm wide, lanceolate, margins entire near pinna apex to strongly dentate further down the pinna, apices generally acute but range to somewhat obtuse, attachment basal to constricted basal, sinuses rounded (pinnules connected along rachis); midvein prominent; secondary veins mostly obscure; fertile foliage consists of sterile pinnae below and fertile pinnae above; fertile portion of frond up to 65 mm long or longer above highest sterile pinna; fertile pinnules highly reduced, alternate, connected along the rachis; venation obscure; sori, sporangia and spores not observed.

OCCURRENCE.—Known from the Dakota Sandstone Formation near Westwater, Grand County, Utah.

REPOSITORY.—Brigham Young University, holotype: BYU 1803.

DISCUSSION.—This fern is known from several specimens collected from the Westwater locality. A few of these are rather complete, illustrating fertile as well as sterile foliage. However, even though fertile specimens have been collected none illustrate sori or sporangia.

C. westwaterensis is similar in some respects to several other species of *Coniopteris*. It perhaps approaches most closely *C. burejensis* (Zalessky) Seward which is a common species from the Mid Jurassic of Asia and has also been collected from Alaska and Europe. *C. westwaterensis* differs from *C. burejensis* (Zalessky) Seward in having less crowded pinnae and by having the fertile portion of the foliage separated from the sterile portion, often occurring as much reduced pinnae apically to sterile pinnae.

C. bella Harris, which is similar to *C. burejensis* (Zalessky) Seward also is similar to *C. westwaterensis*. *C. bella* is only separated from *C. burejensis* based on pinnule margination and fine soral details, and *C. westwaterensis* differs from this fern as from *C. burejensis*. *C. westwaterensis* also differs from both of these ferns in that it exhibits secondary pinnae which are consistently larger, being up to 20 mm wide, whereas the pinnae of *C. burejensis* and *C. bella* are typically 10 mm wide.

Family DIPTERIDACEAE

Genus HAUSMANNIA Dunker

Dunker (1846) proposed this genus for sterile leaf fragments collected from the Wealden of Germany. These fragments were divided by nearly equal ditchotomies to form strap-shaped leaf segments. Subsequent to this time, several other specimens of this genus have been collected, and a rather adequate generic diagnosis has evolved (Harris, 1961).

Hausmannia rigida Newberry

Figs. 9-2, 9-3; 13-4.

1895 *Hausmannia rigida* Newberry—U.S. Geol. Surv. Mon. 27, p. 35, Pl. 1, Figs. 2, 3, 5.

1910 *Newberryana rigida* Berry—Jour. Geol., v. 18, p. 254.

1911 *Newberryana rigida* Berry—Geol. Surv. New Jersey Bull. 3, p. 220.

DESCRIPTION.—Entire leaf unknown, divided to form tongue-shaped pinnules; pinnules typically 9 mm long by 3 mm wide, apices rounded, margins entire, attachment basal with rounded sinuses; midrib prominent, apparently not extending to pinnule apex; secondary veins obscure if present; fertile specimens unknown.

OCCURRENCE.—Known from near Westwater, Grand County, Utah.

REPOSITORY.—Brigham Young University, BYU 1815.

DISCUSSION.—The botanical affinity of *Hausmannia* has been in question in the past. Some early workers considered this plant to be a hepatic. Newberry (1885) said in this connection:

> I have been led to think it possible it was a higher kind of hepatic, a *Marchantia*, for example, lifted from its creeping condition into an independent and erect plant, trained and disciplined into symmetry by the occult in-

Fig. 9. 1. *Astralopteris coloradica* (Brown) Reveal, Tidwell, and Rushforth. Near apical pinna fragment. (X1.2). BYU 1839. 2. *Hausmannia rigida* Newberry. Near apical pinna fragment illustrating tongue-shaped pinnules. (X1.2). BYU 1815. 3. *Hausmannia rigida* Newberry. Enlargement of Fig. 2. (X3). BYU 1815. 4. *Gleichenia delicatula Heer*. Pinna fragment illustrating disposition of ultimate pinnae. (X1.2). BYU 1826. 5. *Cladophlebis crenata* Fontaine. Pinnule fragment illustrating venation. (X3). BYU 1841. 6. *Gleichenia comptoniaefolia* (Deb. and Ett.) Heer. Pinna fragment illustrating disposition of ultimate pinnae. (X1.2). BYU 1816. 7. *Astralopteris coloradica* (Brown) Reveal, Tidwell, and Rushforth. Pinnae fragment. (X1.2). BYU 1840.

> fluence which has given such grace and exactness to the foliage of ferns, lycopods, and some conifers.

Later studies have shown that *Hausmannia* is a fern of the family Dipteridaceae (Richter, 1906), although fertile specimens demonstrating soral characteristics are still unknown. The Westwater *Hausmannia* does not shed any light on this problem since fertile specimens are unknown.

Hausmannia was first treated in America by Newberry (1885) who described *H. rigida*. This species was proposed for several plant fragments collected from the Amboy Clays of New Jersey.

Berry (1910) later transferred *Hausmannia rigida* to the new genus *Newberryana* without description, discussion, or illustration, and hence, his reasons for this move were unknown. However, Berry (1911, p. 220-221) further discussed *Hausmannia rigida* and stated that Newberry had referred this plant to the Hepaticae, and due to this:

> It is, obviously, not related to the genus *Hausmannia*, Dunker, which has been definitely proven to be a fern genus of the family Dipteridaceae, so that I have selected to propose a new generic name. . . .

However, Berry gave no reasons why this plant should not be considered to be related to *Hausmannia*, and further went on to say that indeed it is probably a fern. It is the opinion of the present author that Newberry was justified in placing his material in *Hausmannia* as a new species since this material agrees rather well with the generic diagnosis of *Hausmannia*. Further collections and reevaluation of Newberry's material should, however, be undertaken.

H. rigida Newberry (1895, p. 35, Pl. 1, Figs. 2, 3, 5.) is probably most closely related to the Westwater *Hausmannia*. This species lacks dichotomous leaf divisions, and more regular divisions of the frond-forming tongue-shaped segments is also found in the Westwater species. As discussed by Newberry (1895), the midrib in *H. rigida* gives rise to numerous fine secondary veins, although his illustrations do not demonstrate this feature. These secondary veins cannot be observed in the specimen from Westwater.

H. dichotoma Dunker is a common species of this genus from the Jurassic and Lower Cretaceous of Europe. This species usually has been well described and, as mentioned by Newberry (1895), is closely related to *Hausmannia rigida*. *H. rigida* differs from *H. dichotoma* in that the divisions of the leaf are not dichotomous, and are more regular in the former.

Family GLEICHENIACEAE

Genus GLEICHENIA Smith

Berry (1924) discussed the usage of *Gleichenites* and *Gleichenia*. In this paper, Berry rather strongly supported the use of *Gleichenia* rather than *Gleichenites* and stated in this regard, "It is surely nothing but a mental illusion to imagine that the use of an objectionable term like *Gleichenites* indicates a conservation of judgment." However, Seward (1927) disagreed with Berry and used the name *Gleichenites* for placement of several Greenland species. Seward stated that in his opinion it is a sound practice to use an *ites* ending for a generic name when "either our ignorance or the occurrence of some character in which a fossil species differs from any existing type" may apply to an extinct taxon.

Harris (1961) pointed out that the practice of using genera with an *ites* ending is being dropped by most paleobotanists in recent times. Harris, however, rightfully suggested that when a question exists as to whether a fossil taxon may with equal validity be placed with more than one living taxa, a different generic name for the fossil must be used.

It is my opinion that it is sound to use the *ites* ending under certain circumstances when evidence of the sameness of a fossil and living genus is suggested but not definite. However, the use of this ending merely because of the older age of a fossil is not valid. When there is little or no question that a fossill may be placed in an extant genus, it is both acceptable and desirable to use the modern generic name for its placement.

The fossil section of the genus *Gleichenia* is in urgent need of revision and reevaluation. Many species are undoubtedly synonyms and could be more correctly placed. In addition, this genus affords an excellent opportunity to follow the evolution and migration of a fern genus from Paleozoic to recent times, and its study could contribute greatly to botanical knowledge.

Gleichenia comptoniaefolia (Deb. and Ett.) Heer

Figs. 8-6; 10-1, 10-6; 12-1, 12-3; 13-1, 13-3; 14-3; 20a.

1859 *Didymosarus comptoniaefolia* Deb. and

Fig. 10. 1. *Gleichenia comptoniaefolia* (Deb. and Ett.) Heer. Pinna fragment illustrating disposition of ultimate pinnae. (X1.2). BYU 1821. 2. *Coniopteris westwaterensis* Rushforth, sp. nov. Pinna fragment illustrating disposition of fertile pinnae. (X1.2). Paratype BYU 1804. 3. *Matonidium brownii* Rushforth. Pinna fragment illustrating pinnule disposition. This fragment is somewhat atypical and resembles some species of *Selenocarpus* Schenk. (X1.2). BYU 1833. 4. *Gleichenia delicatula* Heer. Pinna fragment illustrating ultimate pinnae disposition and pinnule shape. (X1.6). BYU 1829. 5. *Matonidium brownii* Rushforth. Pinna fragments and fiddle head. (X1.2). BYU 1834. 6. *Gleichenia comptoniaefolia* (Deb. and Ett.) Heer. Pinna fragment illustrating ultimate pinnae disposition and pinnule shape. (X1.2). BYU 1822.

Ett.—Denkseh. K. Akad. Wiss. Wien., 17, Pl. 1, Figs. 1-5.

1868 *Gleichenia gieseckiana* Heer, pro parte—Flor. Foss. Arct., v. 1, p. 78, Pls. 43, Figs. 1a, 2a, 3a; 44, Figs. 2-3.

1868 *Pecopteris borealis* Brong., Heer, pro parte—Flor. Foss. Arct., v. 1, p. 81, Pl. 44, Fig. 5.

1868 *Gleichenia zippei* (Corda) Heer—Flor. Foss. Arct., v. 1, p. 79, Pl. 43, Fig. 4.

1868 *Pecopteris arctica* Heer, pro parte—Flor. Foss. Arct., v. 1, p. 80, Pl. 43, Fig. 5.

1868 *Pecopteris rinkiana* Heer—Flor. Foss. Arct., v. 1, p. 81, Pl. 44, Fig. 4.

1874 *Gleichenia longipennis* Heer, pro parte—Flor. Foss. Arct., v. 3, pt. 2, p. 46, Pl. 6, Figs. 4-6.

1874 *Gleichenia thulensis* Heer—Flor. Foss. Arct., v. 3, pt. 2, p. 48, Pls. 5, Fig. 9b; 10, Fig. 18.

1874 *Gleichenia comptoniaefolia* (Deb. and Ett.) Heer, pro parte—Flor. Foss. Arct., v. 3, pt. 2, p. 49, Pl. 11, Figs. 1-2.

1874 *Gleichenia gracilis*, Heer, pro parte—Flor. Foss. Arct., v. 3, pt. 2, p. 52, Pl. 10, Fig. 5.

1874 *Gleichenia gieseckiana* Heer—Flor. Foss. Arct., v. 3, pt. 2, p. 43, Pls. 3, 1d, 8; 7, Fig. 1.

1874 *Gleichenia nauckhoffi* Heer—Flor. Foss. Arct., v. 3, pt. 2, Pl. 25, Fig. 4.

1874 *Gleichenia zippei* (Corda) Heer, pro parte—Flor. Foss. Arct., v. 3, pt. 2, p. 44, 90, 97, Pls. 4-7; 25, Figs. 1-3.

1874 *Pecopteris hyperborea* Heer—Flor. Foss. Arct., v. 3., pt. 2, p. 41.

1874 *Gleichenia kurriana* Heer, Lesquereux—U.S. Geol. Surv. Terr. Rept., v. 6, p. 47, Pl. 1, Figs. 5, 5b, 5c.

1882 *Gleichenia geiseckiana* Heer—Flor. Foss. Arct., v. 6, pt. 2, p. 6, Pl. 2, Fig. 9.

1882 *Gleichenia zippei* (Corda) Heer—Flor. Foss. Arct., v. 6. pt. 2, p. 7, Pl. 3, Fig. 2.

1882 *Gleichenia longipennis* Heer—Flor. Foss. Arct., v. 6, pt. 2, p. 7, Pl. 2, Fig. 5.

1882 *Gleichenia comptoniaefolia* (Deb. and Ett.) Heer—Flor. Foss. Arct., v. 6, pt. 2, p. 8, 36, Pl. 46, Fig. 25.

1883 *Gleichenia nordenskioldi* Heer, Lesquereux—U.S. Geol. Surv. of Terr. Repts., v. 8, p. 26, Pl. 1, Figs. 1, 1a.

1889 *Gleichenia nordenskioldi* Heer, Fontaine—U.S. Geol. Surv. Mon. 15, p. 119, Pl. 21, Fig. 11.

1889 *Gleichenia zippei* (Corda) Heer, Fontaine—in Ward, U.S. Geol. Surv. 19th Ann. Rept., p. 664, Pl. 162, Fig. 9.

1927 *Gleichenites gieseckiana* (Heer) Seward—Phil. Trans. Roy. Soc. London B, v. 215, p. 69, Pl. 5, Figs. 1-4, 6-14, 16, 17; Pl. 10, Fig. 96; Pl. 12, Fig. 118; text-Fig. 2.

1950 *Gleichenia kurriana* Heer, Brown—U.S. Geol. Surv. Prof. Paper 221-D, p. 48, Pl. 10, Figs. 5-6.

1956 *Gleichenia gieseckiana* (Heer) Seward, Bell—Geol. Surv. Can. Mem. 285, p. 61, Pl. 17, Figs. 1, 2; Pl. 18, Fig. 5.

DESCRIPTION.—Entire leaf unknown, at least bipinnate; rachis stout, slightly greater than 1 mm in diameter, smooth, appearing dichotomously branched (although not truly dichotomizing [Bower, 1926]), with a bud in the axil of dichotomy; ultimate pinnae alternate, occasionally subopposite, nearly linear, approximately 80 mm long by 10 mm wide; pinnules arising obtusely from rachis, narrow eliptic to deltoid near pinna apex, oriented slightly toward pinna apex, ranging from 1 mm wide by 2 mm long at apex of pinna to 3 mm wide by 6 mm long near pinna base, margins entire, apices obtuse; major vein strong at point of origin, not extending to pinnule apex; secondary veins numerous, dividing, extending to pinnule margins; sori commonly three per pinnule, round; sporangia and spores unknown.

OCCURRENCE.—Near Westwater, Grand County, Utah, and Rabbit Valley, Grand County, Utah. REPOSITORY.—Brigham Young University, BYU 1816-1825, 1853a.

DISCUSSION.—As may be deduced from the synonomy for *G. comptoniaefolia*, Heer proposed many species of *Gleichenia* in the late 1800s based upon material collected from several Greenland localities. Heer treated any form that illustrated any variation whatsoever as a new species. Seward (1927) reviewed the work of Heer and studied many of his original collections. Based upon his studies, Seward concluded that many of the species proposed by Heer merely represent variations of a few species.

In discussing the synonomy for *G. gieseckiana*, into which Seward (1927) lumped many of Heer's (1868, 1874, 1872) species, Seward mentions two names which predate *G. gieseckiana*. The first of these *Pecopteris borealis* Brongniart, was applied by Brongniart (1828). Seward ex-

Fig. 11. 1. *Cladophlebis constricta* Fontaine em. Berry. Pinnules illustrating deeply lobed margins. (X3). BYU 1941. 2. *Cladophlebis parva* Fontaine em. Berry. Pinna fragment illustrating pinnule shape and venation. (X3). BYU 1842. 3. *Asplenium dicksonianum* Heer. Pinna fragment illustrating shape and venation of pinnules. (X3). BYU 1814. 4. *Coniopteris westwaterensis* Rushforth, sp. nov. Portion of pinna illustrating pinnule shape and margination. (X3). Paratype: BYU 1805. 5. *Asplenium dakotensis* Rushforth, sp. nov. Portion of frond illustration pinnae and pinnule disposition. (X3). Holotype: BYU 1806.

amined the type specimen of this fern and concluded that it was not possible to determine if it is synonomous with *G. gieseckiana*. Later collections from the probable locality where *P.borealis* was collected have turned up specimens which are identical with *G. gieseckiana*. However, since the original type specimen is not identifiable, Seward chose to retain Heer's specific epi-

Didymosarus comptoniaefolius Deb. and Ett. that.
(1859) is also an older name which has been applied to *G. gieseckiana* Heer. Heer recombined *D. comptoniaefolius* Deb. and Ett. as *Gliechenia gieseckiana* since the former is undoubtedly gleicheniaceous. Seward (1927) placed *G. comptoniaefolia* (Deb. and Ett.)Heer in synonomy with *G. gieseckiana* Heer. Seward did not use the oldest specific epithat because "evidence of identity is not convincing." However, Seward in the same paper noted that some of the ferns Heer had placed in *G. comptoniaefolia* were,without question, referable to *G. gieseckiana*. Furthermore, the illustrations of Debey and Ettinghausen (1859) indicate that it is very likely that the ferns referred by them to *Didymosarus comptoniaefolius* are identical to *G. gieseckiana*. In view of this, it is preferable to use the oldest specific epithat, and therefore the most acceptable binomial applied to *G. gieseckiana* of Heer, is G. *comptoniaefolia* (Deb. and Ett.) Heer.

Lesquereux (1874) figured a gleichenious fern from the Dakota Group of Kansas. These ferns agree in every detail with *Gleichenia comptoniaefolia* (Deb. and Ett.) Heer, but were placed in *Gleichenia kurriana* Heer by Lesquereux. However, it is important to note that Lesquereux considered the Dakota ferns closely allied to *Didymososorus comptoniifolius* Deb. and Ett., and in fact noted that in pinnule shape, disposition, and venation, "our American species or variety would be more closely related to *Didymososorus comptoniifolius* Deb. and Ett. . ."

Lesquereux (1883) again treated gliechenious ferns in his work on the Cretaceous and Tertiary of the Western Territories. Pinna fragments of *Gleichenia* from the Dakota Group were placed by Lesquereux in *G. nordenskioldi*. However, as noted by Seward (1927) the fern examined by Lesquereux agrees in all respects with *G. gieseckiana* (*G. comptoniaefolia*).

Fontaine (1889) discussed *Gleichenia nordenskioldi* Heer as known from the Potamac Group. However, this fern agrees with *G. comptoniaefolia* closely, and should be placed in this species.

In discussing Lower Cretaceous plants from the Black Hills region, Fontaine (1899) again discussed gleicheniaceous ferns. He placed a specimen of *Gleichenia* in *G. zippei* (Corda) Heer. This fern likewise is very similar to *G. comptoniaefolia*, and can be correctly considered in this species.

Velenovsky (1888) described and illustrated several fossil ferns with gleichenious affinities collected from the European Cretaceous. Two of these which are very similar to *G. comptoniaefolia* are *G. zippei* (Corda) Heer and *G. multinervosa* Velen.

Brown (1950) reported on gleichenious fossils from the Dakota Sandstone of southwestern Colorado. He placed these ferns in *Gleichenia kurriana* following Lesquereux (1874). Recent examination of these ferns by the present author indicates that they are indeed very similar to those figured by Lesquereux (1874) as *G. kurriana* which are correctly placed with *G. comptoniaefolia*.

Bell (1956) described *Gleichenites gieseckianus* Heer em. Seward from several localities in western Canada. These ferns agree with the Westwater *Gleichenia* in all respects except that the pinnules on the Canadian specimens are often somewhat reflexed. Again, these ferns are correctly classified as *Gleichenia comptoniaefolia* (Deb. and Ett.) Heer.

Seward (1927) discussed *Gleichenites nordenskioldi* Heer, and retained it as a valid species which differs from *G. comptoniaefolia* by having long pinna of uniform breadth and pinnules with somewhat more frequent veins. Soriation in the two species is similar, but Seward noted that *G. nordenskioldi* has more sori per pinnule. All of these features are extremely variable, and specimens from Westwater may be found intermediate to all of these species-differentiating characteristics. However, the author has elected not to make any changes in classical usage of *G. nordenskioldi* and *G. comptoniaefolia* until further review.

Gleicheneous fossils from the Westwater locality are similar to those figured by Heer (1868, 1874, 1882), Seward (1927), and others. Similar problems of classification have been encountered with these ferns in that they exhibit rather wide morphologieal variation. However, the present author has elected to be more conservative than Heer and Seward, and many fossils which exhibit some degree of variation are nonetheless placed in *G. comptoniaefolia* (Deb. and Ett.) Heer.

This species of fern is the most common element from the Westwater area and it is present in such profusion that at certain outcroppings one can scarcely break open a rock without exposing at least one beautiful specimen. It is in-

Fig. 12. 1. *Gleichenia comptoniaefolia* (Deb. and Ett.) Heer. Pinna illustrating ultimate pinnae and pinnules. (XI.2). BYU 1818. 2. *Asplenium dicksonianum* Heer. Pinna fragment illustrating disposition of ultimate pinnae. (XI.2). BYU 1812. 3. *Gleichenia comptoniaefolia* (Deb. and Ett.) Heer. Pinna illustrating ultimate pinnae and pinnules. (XI.2). BYU 1819. 4. *Salix newberryana* Hollick. Leaf demonstrating characteristic shape and margination. (XI.2). BYU 1851. 5. *Ilex serratus* Rushforth, sp. nov. Leaf illustrating shape and margination. (XI.2). Paratype: BYU 1802. 6. *Asplenium dakotensis* Rushforth, sp. nov. Pinna illustrating shape and disposition of ultimate pinnae and pinnules. (XI.2). Holotype: BYU 1806.

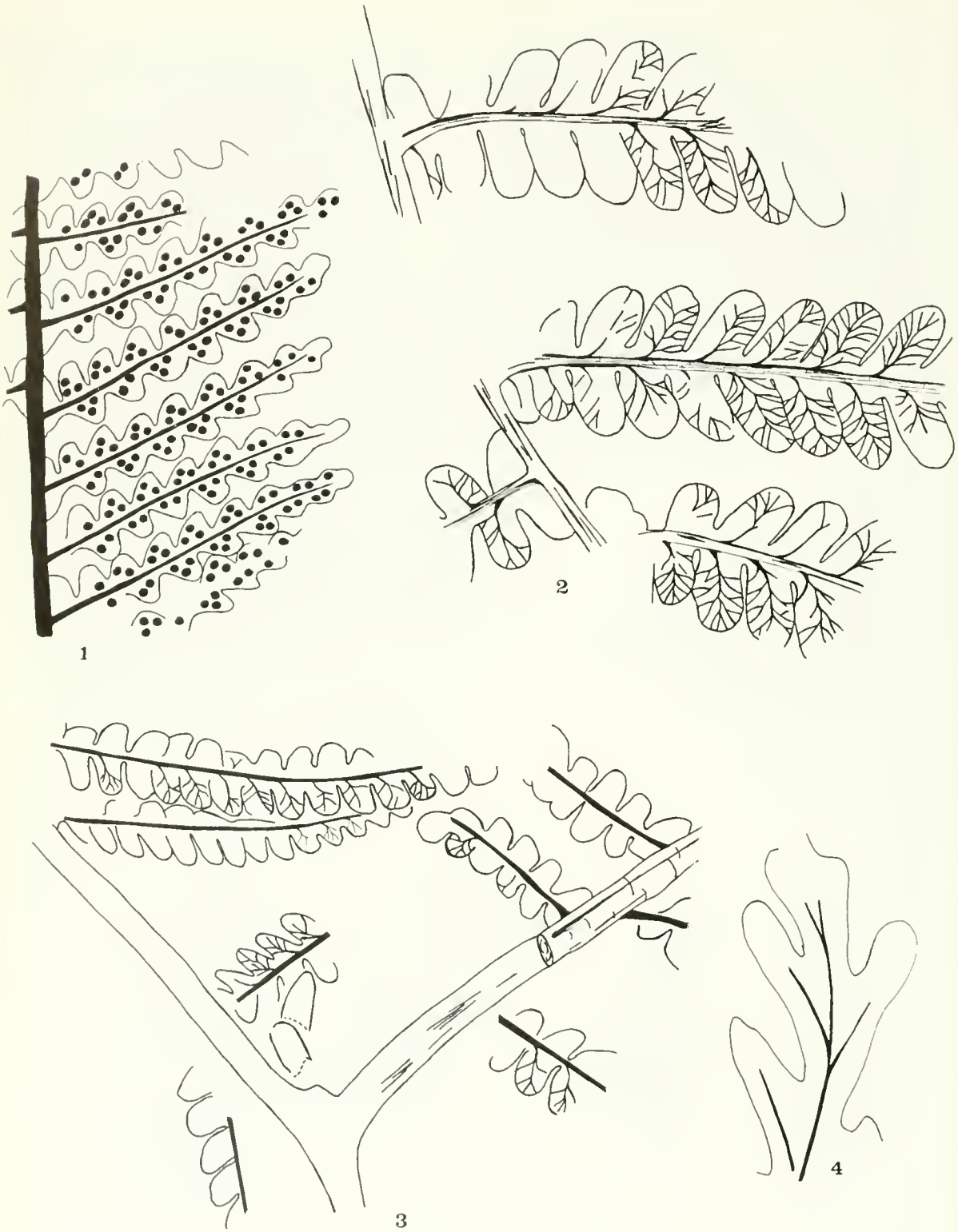

FIG. 13. 1. *Gleichenia comptoniaefolia* (Deb. and Ett.) Heer. Pinna fragment illustrating soral disposition. (X3). BYU 1823. 2. *Gleichenia comptoniaefolia* (Deb. and Ett.) Heer. Pinnae fragments with pinnules exhibiting venation. (X3). BYU 1824. 3. *Gleichenia compltoniaefolia* (Deb. and Ett.) Heer. Pinna fragment illustrating characteristic branching. (X3). BYU 1825. 4. *Hausmannia rigida* Newberry. Pinnae fragment demonstrating tongue-shaped pinnules. (X3). BYU 1815.

teresting to note that gleicheniaceous ferns are also most common from the Greenland Cretaceous flora. Indeed, as mentioned by Seward, ". . . part of the country was occupied by a vertiable Gleichenietum."

Gleichenia delicatula

Figs. 7-1, 7-2, 7-4; 8-1, 8-3; 9-4; 10-4.

1874 *Gleichenia delicatula* Heer—Flor. Foss. Arct., v. 3, pt. 2, p. 54, Pl. 9, Figs. 11e, 11f; Pl. 10, Figs. 16, 17.

1882 *Gleichenia delicatula* Heer—Flor. Foss. Arct., v. 6, pt. 2, p. 9.

1888 *Gleichenia delicatula* Heer, Velenovsky—Abh. K. Bohm. Ges. der Wiss., Math.-Natw., ser. 7, v. 1, p. 7, Pl. 3, Figs. 12-14.

1910 *Gleichenites delicatula* (Heer) Seward—Fossil Plants: v. 2, p. 354, Fig. 262b.

1919 *Gleichenia delicatula* Heer, Berry—U.S. Geol. Surv. Prof. Pap. 112, p. 54.

Description.—Entire leaf unknown, at least bipinnate; petiole less than 1 mm in diameter, smooth, appearing dichotomously branched with a bud in the axis of dichotomy; ultimate pinnae alternate, linear, up to 15 mm long by 2 mm wide; pinnules tending toward ovate but with truncated edge toward pinna apex, oriented slightly toward pinna apex, approximately 1 mm long by 1.2 mm wide, attachment basal with rounded sinuses, margins entire, apices acute to obtuse, directed apically; primary vein dividing immediately upon arising from rachis; secondary veins dividing, giving rise to three to five ultimate veinlets which extend to pinnule margin; fertile specimens unknown.

Occurrence.—Near Westwater, Grand County, Utah, and Rabbit Valley, Grand County, Utah

Repository.—Brigham Young University, BYU 1826-1730.

Discussion.—*Gleichenia delicatula* was proposed by Heer in 1874 for placement of several pinna fragments collected from the Greenland Cretaceous. This fern was originally described by Heer (1874) as follows:

> Gl. fronde gracillima, dichotoma, bipinnata, racchi tennuissima, pinnis approximatis, patentibus, linearibus, pinnulis minutissimus, rotundatus.

This description, and the illustrations of Heer agree rather well with the Westwater specimens. One readily apparent difference is the pinnule shape, which as described by Heer is round in the Greenland specimens, but tends toward ovate with an angular apex in the Westwater material. In the oblong pinnule shape, the Utah material resembles *Gleichenia micromera* Heer, a contemporaneous species with *G. delicatula*. However, the westwater material is dissimilar to *G. micromera* in that the pinnules in the latter are not attached to the rachis with their entire base, whereas, they are broadly attached and with rounded sinuses in the Utah *Gleichenia*.

Velenoesky (1888) discussed and figured two specimens of *Gleichenia delicatula*. These specimens agree in all details with Heer's (1874) specimens, and differ from the Westwater specimens only in pinnule shape. Pinna morphology and size of Velenovsky's specimens is identical to that of the Utah *Gleichenia*.

Seward (1910) used the generic name *Gleichenites* for the placement of *Gleichenia delicatula*. He made no changes in description, and figured a specimen of *Gleichenia delicatula* which appears very close to those of Heer (1874), Velenovsky (1883), and the material from Utah. Again, the pinnule shape varies between Seward's specimens and those from Utah.

Berry (1919) reported on *Gleichenia delicatula* collected from the Tuscaloosa Formation of Fayette County, Alabama. This fern was placed with *G. delicatula* based upon the pinnules being united to the rachis along their entire base. Berry further mentioned that Fontaine (1895) had wrongly placed pinna fragments collected from the Raritan Formation in *G. micromera*. Berry placed these in *G. delicatula* based upon their completely basal attachment. Again, this fern is similar in size to the Westwater fern, but pinnule shape differs somewhat.

Even though in pinnule shape the Westwater *Gleichenia* differs somewhat from other small pinnuled species of this genus, for the present time the author has elected to place it with *G.delicatula* Heer. This placement is based upon similar pinna morphology and pinnule size and disposition.

Family MATONIACEAE

Genus MATONIDIUM Schenk

Schenk (1871) was the first to use the generic name *Matonidium* for placement of fossil ferns exhibiting similar characteristics as the extant *Matonia pectinata* R. Br. Fossil ferns placed in this genus are morphologically very similar

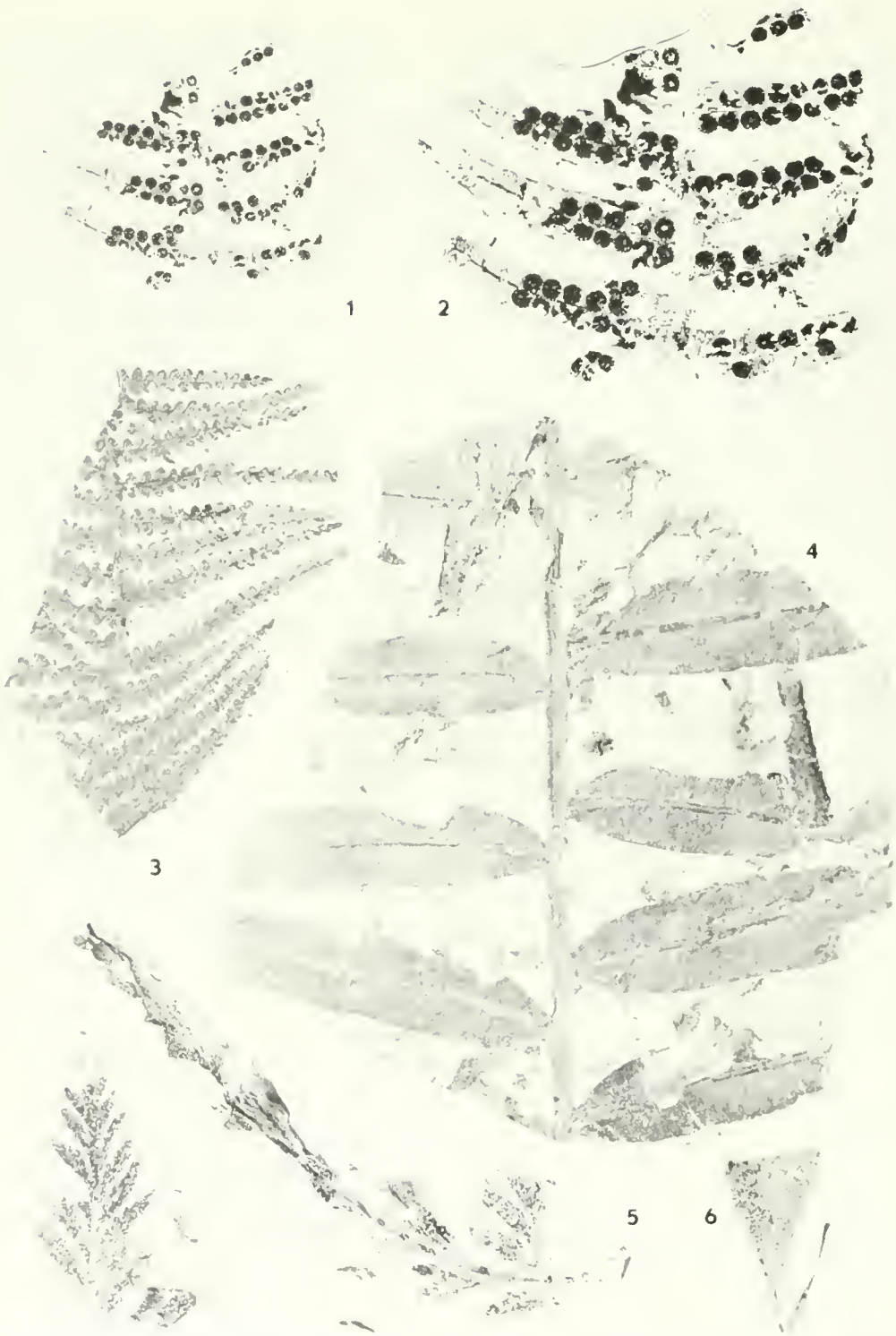

FIG. 14. 1. *Matonidium brounii* Rushforth. Pinna fragment illustrating venation and soriation of pinnules. (X1.2). BYU 1563. 2. *Matonidium brounii* Rushforth. Enlargement of Fig. 1. (X2.7). BYU 1563. 3. *Gleichenia comptoniaefolia* (Deb. and Ett.) Heer. Pinna fragment illustrating ultimate pinnae disposition. (X1.2). BYU 1820. 4. *Astralopteris coloradica* Reveal, Tidwell, and Rushforth. Pinna fragment illustrating pinnule attachment and shape. (X1.2). BYU 1838. 5. *Coniopteris westwaterensis* Rushforth, sp. nov. Sterile and fertile pinnae. (X1.2). Holotype: BYU 1803. 6. Angiosperm leaf base possibly belonging to *Ficus* sp. (X1.2). BYU 1847.

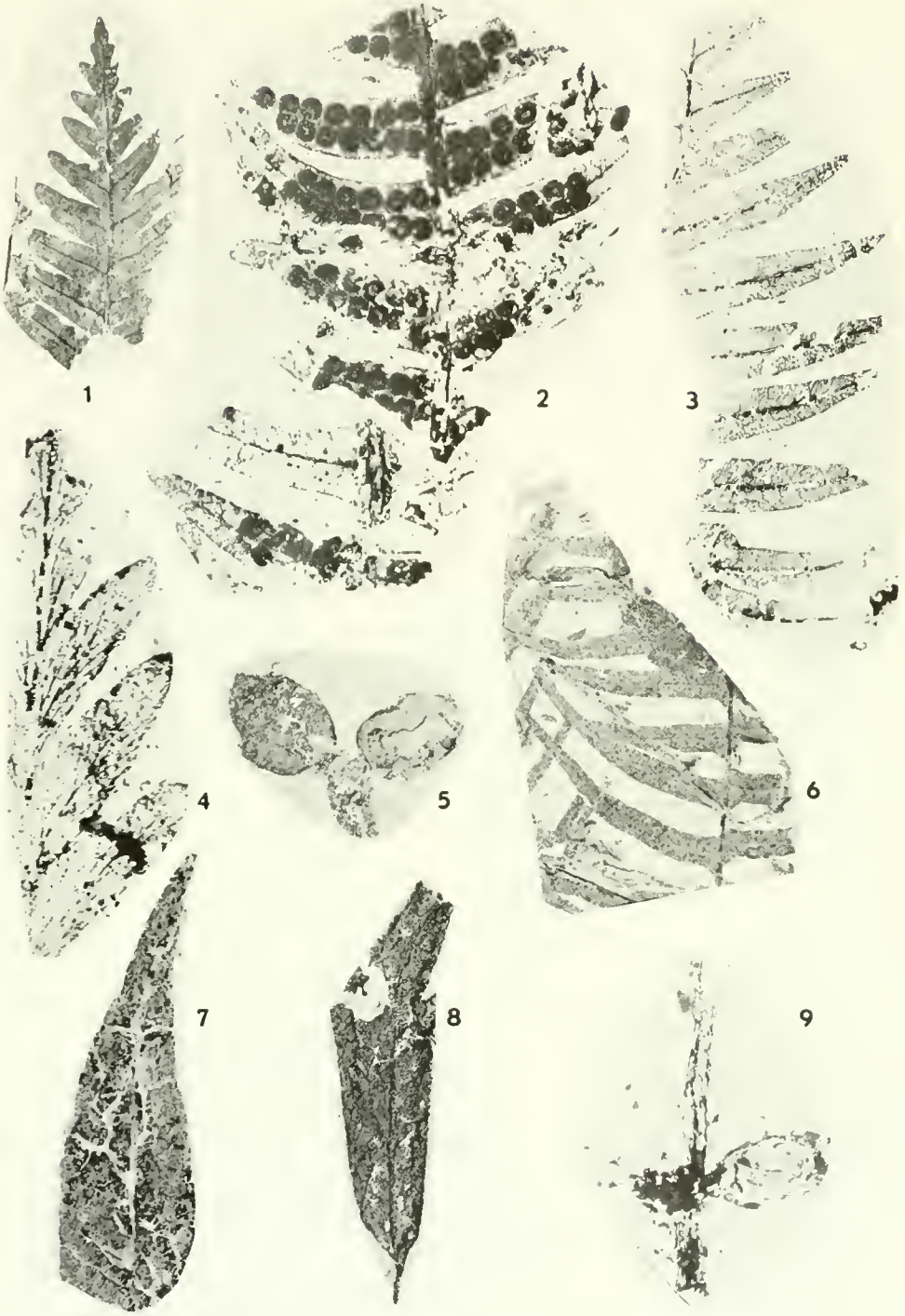

Fig. 15. 1. *Matonidium brownii* Rushforth. Pinna apex demonstrating disposition of pinnules. (X1.2). BYU 1832 2. *Matonidium brownii* Rushforth. Pinna fragment demonstrating venation and soriation. (X2.8). Paratype: BYU 1559. 3. *Matonidium* (?) *lanicipinnulum* Rushforth. Pinna transfer illustrating pinnule shape and disposition. (X1.5). Holotype: BYU 1569. 4. *Asplenium dicksonianum* Heer. Pinna transfer illustrating pinnule disposition and venation. (X2.4). BYU 1813. 5. *Equisetum lyelli* Mantel. Portion of rhizome with two tubers attached. (X1.2). BYU 1807. 6. *Matonidium brownii* var. *magnipinnulum* Rushforth. Pinna fragment showing long, linear pinnules. (X1.2). BYU 1836. 7. *Salix newberryana* Hollick. Leaf demonstrating characteristic shape and size. (X1.2). BYU 1850. 8. *Eucalyptus dakotensis* Lesquereux. Leaf of characteristic size and shape. (X1.2). BYU 1848. 9. *Equisetum lyelli* Mantel. Rhizome transfer with attached tubers. (X1.2). BYU 1808.

and often essentially identical to modern matoniaceous ferns.

Matonidium is often difficult to differentiate from other members of the Matoniaceae, particularly *Phlebopteris*. However, *Matonidium* is separated from *Phlebopteris* based upon the presence of an indusium in the former. This difference is often very difficult to determine even in fertile specimens, and is impossible to ascertain in sterile material. Furthermore, to compound this problem, *Matonidium* and *Phlebopteris* are often very similar in venation. Further work dealing with this family will likely show that the distinction between these two genera is unnatural and that ferns variously placed in the two should be classified under a single genus.

Matonidium americanum Berry em. Rushforth

Figs. 18-3, 18-4; 19-5.

1916 *Matonidium althausii* (Dunker) Ward, Cockerell—J. Wash. Acad. Sci., v. 6, p. 111, Fig. 2.

1916 *Cycadospadix* sp. Cockerell—J. Wash. Acad. Sci., v. 6, p. 111, Fig. 1.

1918 *Matonidium americanum* Berry—Bull. Torrey Bot. Club, v. 46, p. 287, Fig. 2. Pls. 12, Figs. 1-12; 13, 3-6.

1970 *Matonidium americanum* Berry, Rushforth —BYU Geol. Stud., v. 16, pt. 3, p. 25, Pl. 8, Fig. 1; Pl. 13, Fig. 2.

DESCRIPTION.—Fronds pedate, petiole stout, to approximately 1 cm in diameter, furrowed (?), dividing to form a collar from which pinnae are born; pinnae lanceolate to linear, 20 cm to 25 cm long, up to 39 per frond; pinnules inserted near the upper margin of the rachis, up to 9 mm long by 3 mm wide, coriaceous, more or less falcate; apices rounded; margins entire or revolute; midvein prominent to near the pinnule apex; secondary veins prominent, bifurcate approximately one-half to two-thirds of the way to margin, remain free; sori biseriate, round (except where crowded), decrease in size toward pinnule apex, indusiate; indusium peltate; sporangia and spores unknown.

OCCURRENCE.—Near Cutthroat Gulch and Hovenweep Canyon west of Dolores, Montrose County, Colorado, and Rabbit Valley, Grand County, Utah.

REPOSITORY.—Brigham Young University, BYU 1572, 1831.

DISCUSSION.—As mentioned by Berry (1919) the pinnules of *M. americanum* are coriaceous. This feature is easily discerned in the specimens examined by the present author and may be the reason that venation in this species is poorly preserved. Berry also described the pinnules of this species as having revolute margins. While this is possible, it is likely that this appearance is due to the coriaceous nature of the pinnules. This feature is quite unique within the Matoniaceae.

This species also differs from other species of *Matonidium* in the large number of pinnae borne on a single frond. In addition, the open venation pattern is somewhat uncommon although not unprecedented within the Matoniaceae.

Matonidium brownii Rushforth

Figs. 10-3, 10-5; 14-1, 14-2; 15-1; 17; 18-2; 18-1, 18-3. 18-6.

1950 *Matonidium americanum* Berry, Brown—U.S. Geol. Surv. Prof. Paper 221-D, p. 48, Pl. 10, Figs. 7-8.

1970 *Matonidium brownii* Rishforth—BYU Geol. Stud. 16(3), p. 9, Pl. 1, Fig. 2; Pls. 2-5; Pl. 6, Fig. 2; Pl. 8, Fig. 2; Pl. 11, Fig. 1.

DESCRIPTION.—Petiole stout, between 5 mm and 15 mm in diameter, divided apically into two short arms; pinnae four to ten or more per frond, lanceolate, up to 14 cm in length, pinna rachis between 0.5 mm and 2.5 mm in diameter; pinnules opposite to alternate, basal in attachment, decurrent but free from each other, up to 30 mm in length by 9 mm in width, arise nearly perpendicular to the rachis but become oriented toward pinna apex; margins entire; apices rounded; midrib prominent to pinnule apex; secondary veins arise from midrib, divide to form costal aeroles; tertiary veins arise from costal areole and other secondary veins and anastomose in the pinnule lamina; costal areoles absent in fertile specimens; secondary veins form an arch above placenta; tertiary veins arise from this arch and extend to the placenta; upper epidermal cells more or less isodiametrie, average 45u in diameter; lower epidermal cells unknown; sori round, biseriate 1.7 mm to 2.9 mm in diameter, with a single ring of from ten to fourteen sporangia; indusia present, peltate, persistent; sporangia cuneate sessile or nearly so; annuli oblique; spores trilete, laesurae three quarters of the distance to the equator, rounded-triangular, 57u in diameter, with a weak margo.

OCCURRENCE.—Known from near Naturita, Montrose County, Colorado, and near Westwater, Grand County, Utah.

Fig. 16. 1. *Magnolia boulayana* Lesquereux. Leaf of characteristic size and shape. (X1.2). BYU 1843. 2. *Ilex serrata* Rushforth sp. nov. Angular-ovate leaf with typical serrate to spinose margin. (X1.2). Holotype: BYU 1801. 3. *Ficus daphnogenoides* (Heer) Berry. Cuneate leaf base exhibiting cuneate base. (X1). BYU 1845. 4. *Ficus daphnogenoides* (Heer) Berry. Leaf exhibiting drip point, shape and margination. (X1). BYU 1846. 5. Poorly preserved angiosperm leaf possibly of *Magnolia* sp. (X1). BYU 1844. 6. *Platanus newberryana* Heer. Portion of leaf exhibiting characteristic venation. (X1.5). BYU 1849.

REPOSITORY.—Brigham Young University, holotype: BYU 1557; paratypes: BYU 1559, 1563; BYU 1832-1835.

DISCUSSION.—*M. brownii* was first described by Brown (1950) from specimens collected from the Dakota Sandstone of southwestern Colorado. However, Brown placed this fern in *M. americanum* Berry. The present author examined the specimens collected from this locality and concluded that these specimens should not be placed with *M. americanum*. Due to this, *M. brownii* Rushforth (1970) was proposed.

M. brownii differs from *M. americanum* by being much larger; by having fewer pinnae per frond; by having anastomosing rather than open venation; and in soriation (Rushforth, 1970).

M. brownii differs from a related species, *M. wiesneri* Krasser, by having anastomosing rather than open venation; by being larger in overall size; and by having more numerous sori. *M. althausii* (Dunker) Ward differs from *M. brownii* in pinnule shape and habit, and in venation. Soriation of *M. althausii* also differs from *M. brownii* in that the former exhibits sori born to the extreme pinnule apex decreasing in size as the apex is approached.

In venation *M. brownii* is similar to *Phlebopteris* (Schenk) Schenk.

Matonidium brownii var. *magnipinnulum* Rushforth

Figs. 15-6; 18-2; 21b.

1970 *Matonidium brownii* var. *magnipinnulum* Rushforth—BYU Geol. Stud., v. 16, pt. 3, p. 11, Pl. 6, Fig. 1; Pl. 7, Fig. 2; Pl. 14, Fig. 2.

DESCRIPTION.—Entire leaf unknown, pedate; pinnae observed up to 30 cm long, longer in growth, lanceolate; rachis up to 1.5 mm in diameter; pinnules opposite to alternate, basal in attachment, often decurrent, free, up to 60 mm in length by 6 mm in width, arise at 90° but become oriented toward pinna apex; margins entire; apices rounded; midvein prominent to pinnule apex; secondary veins prominent, forming costal areoles in sterile pinnules, progressing directly to placenta in fertile forms; tertiary veins often anastomose except in pinnule tips; lower epidermal cells large (up to 95u by 45u), lobed; fertile specimens not observed.

OCCURRENCE.—Known from the Dakota Sandstone Formation near Westwater, Grand County, Utah.

REPOSITORY.—Brigham Young University, holotype: BYU 1566; BYU 1836.

DISCUSSION.—*M. brownii* var. *magnipinnulum* was described by Rushforth (1970) for matoniaceous frond fragments from the Westwater flora. In pinnule habit and venation *M. brownii* var. *magnipinnulum* is very similar to *M. brownii* var. *brownii*. However, the pinnules of var. *magnipinnulum* are consistently longer and narrower than those of var. *brownii*. In addition, the disposition of the pinnules on the rachis is farther apart in var. *magnipinnulum*.

As mentioned by Rushforth (1970), this fern may be distinguished from other matoniaceous ferns due to its large pinna and pinnule size. However, long, linear pinnules are not unknown within the Matoniaceae. Bell (1956) reported on *Phlebopteris* (?) *elongata* for sterile pinna fragments from the Cretaceous of Canada, and *P. muensteri* also exhibits long linear pinnules.

Matonidium (?) *lancipinnulum* Rushforth

Figs. 15-3; 18-1; 19-2.

1970 *Matonidium* (?) *lancipinnulum* Rushforth BYU Geol. Studies, v. 16 pt. 3, p. 24, Pl. 7, Fig. 1; Pl. 9; Pl. 10; Pl. 13, Fig. 1.

DESCRIPTION.—Entire leaf unknown; pinnules sub-opposite, linear-lanceolate, 60 mm long by 12 mm wide, essentially perpendicular to rachis except at extreme pinnule apex, attachment basal with rounded sinuses; midvein prominent to pinnule apex; secondary veins prominent, forming costal areoles, anastomosing above costal areoles except near laminar edge, composed of tracheids with annular, helical and reticulate wall thickenings; guard cells 40u long by 15u wide, leaving stomata 10u wide; fertile specimens unknown.

OCCURRENCE.—Dakota Sandstone Formation near Westwater, Grand County, Utah.

REPOSITORY.—Brigham Young University, holotype: BYU 1569; paratype: BYU 1579.

DISCUSSION.—Rushforth (1070) placed this fern in the Matoniaceae based upon pinnule venation and shape. However, the assignment of this fern to this family must remain provisional until fertile specimens are collected.

One interesting fact concerning this fern is that it seems to be somewhat intermediate in venation pattern between well-defined members of the Matoniaceae and another Westwater fern, *Astralopteris* (Polypodiaceae). This latter genus illustrates venation which would tend to align it with the Matoniaceae, but soral characteristics align it with the Polypodiaceae. Further at-

Fig. 17. *Matonidium brownii* Rushforth. Portion of a frond illustrating pinnae and pinnule disposition. (X1.2). Holotype: BYU 1557.

tempts to locate more specimens of *M. lancipinnulum* are presently under way.

Family POLYPODIACEAE

Genus ASTRALOPTERIS Reveal, Tidwell and Rushforth

Astralopteris coloradica (Brown) Reveal, Tidwell and Rushforth

Figs. 9-1, 9-7; 14-4; 19-4; 20.

1950 *Bolitis coloradica* Brown—U.S. Geol. Surv. Prof. Paper 221-D, p. 49, Pl. 12, Figs. 6-7.
1967 *Astralopteris coloradica* (Brown) Reveal, Tidwell and Rushforth, Tidwell *et al.*—BYU Geol. Studies, v. 14, p. 239, Pl. 2, Fig. 1; Pls. 3-6.
1968 *Astralopteris coloradica* (Brown) Reveal, Tidwell and Rushforth, Rushforth and Tidwell—BYU Geol. Studies, v. 15, p. 109, Pls. 1-3.

DESCRIPTION.—Entire frond unknown; pinnae incomplete, large, ovate, tapering to rather acute apices; pinnules coriaceous, pinnate, alternate to opposite on rather stout rachises; lower pinnules linear-lanceolate, about 7 to 11 times as long as broad, sessile to short stalked attachment; margins entire; apices acute to rounded; upper pinnules similar to lower ones, 4 to 5 times as long as broad, basal attachment with rounded sinuses in the uppermost pinnules; midvein prominent to the pinnule apex or nearly so, arising decurrently from rachis; lateral veins numerous arising acutely and then becoming nearly at right angles to the midvein (or divaricate) for nearly their entire length, simple for one-half to three-quarters or more of their length then usually bifurcating two or three times (or rarely trifurcating at the first fork); ultimate veins finer, anastomosing, often obscure; sori round, biseriate between the main lateral veins, about one-fourth of the distance from the midrib to the margin, fed from a costal areole and other secondary veins which extend to the placenta; sporangia 12 to 15, arranged in a ring around a central placenta; annuli vertical; spores unknown.

OCCURRENCE.—Known from the Dakota Sandstone Formation near Westwater, Grand County, Utah.

REPOSITORY.—Brigham Young University, BYU 1415-1422; 1837-1840.

DISCUSSION.—*A. coloradica* was originally described as *Bolbitis coloradica* by Brown (1950). This placement was based upon sterile specimens collected from Naturita, Montrose County, Colorado. Brown encountered difficulty in placing this fern and consequently he conferred with extant fern workers from the Smithsonian Institute. These workers suggested that in overall gross morphology (pinnule shape, size, venation, etc.) the Naturita fossils are similar to ferns of the extant genus *Bolbitis*.

Tidwell et al. (1967) reported fertile specimens of this fern and illustrated that this fern could not be placed in the extant *Bolbitis*. Furthermore, since no living or fossil genus allowed for the placement of this fern the new genus *Astralopteris* was proposed.

A. coloradica is one of the most common elements of the Westwater flora. In some collecting sites it is collected almost exclusively, although it is most commonly collected in association with *Matonidium* and *Gleichenia*. Collections of fertile specimens of this fern are rare at the Westwater locality but, from recent examinations by the author, appear to be somewhat more common from the Dakota Sandstone of southwestern Colorado and Arizona.

UNCLASSIFIED FERNS

Genus CLADOPHLEBIS Brongniart

This generic name was originally proposed by Brongniart (1849) but Saporta (1873) first defined (*Cladophlebis*) as follows:

> Frond pinnately divided; pinnules separate from one another, or slightly united, attached by the entire base.

Schimper (1874) emended this diagnosis to:

> Fronds pinnately divided; pinnae spreading; lobes or pinnules attached by the entire base, sometimes confluent, rarely slightly auriculate, accuminate or obtuse, occasionally dentate, especially at the apex, not rarely subfalcately curved upwards; midnerves pretty strong; secondary nerves departing at a more or less acute angle, dichotomous; slender to very slender.

Fontaine (1889) modified this diagnosis only in regard to venation by saying, ". . . midnerve strong at base, and towards the summit dissolving into branches."

Fontaine (1889) discussed the usage of *Cladophlebis* and concluded that it is a useful genus for placement of sterile foliage which may be described as above. This is indeed the case, as foliage assigned to *Cladophlebis* could fit well into a number of different genera. Therefore, *Cladophlebis* has become a useful, though unnatural genus which is very characteristic of the Mesozoic, particularly of Jurassic times. Thus Berry (1912) mentioned that *Cladophlebis* is essentially a form genus and includes species

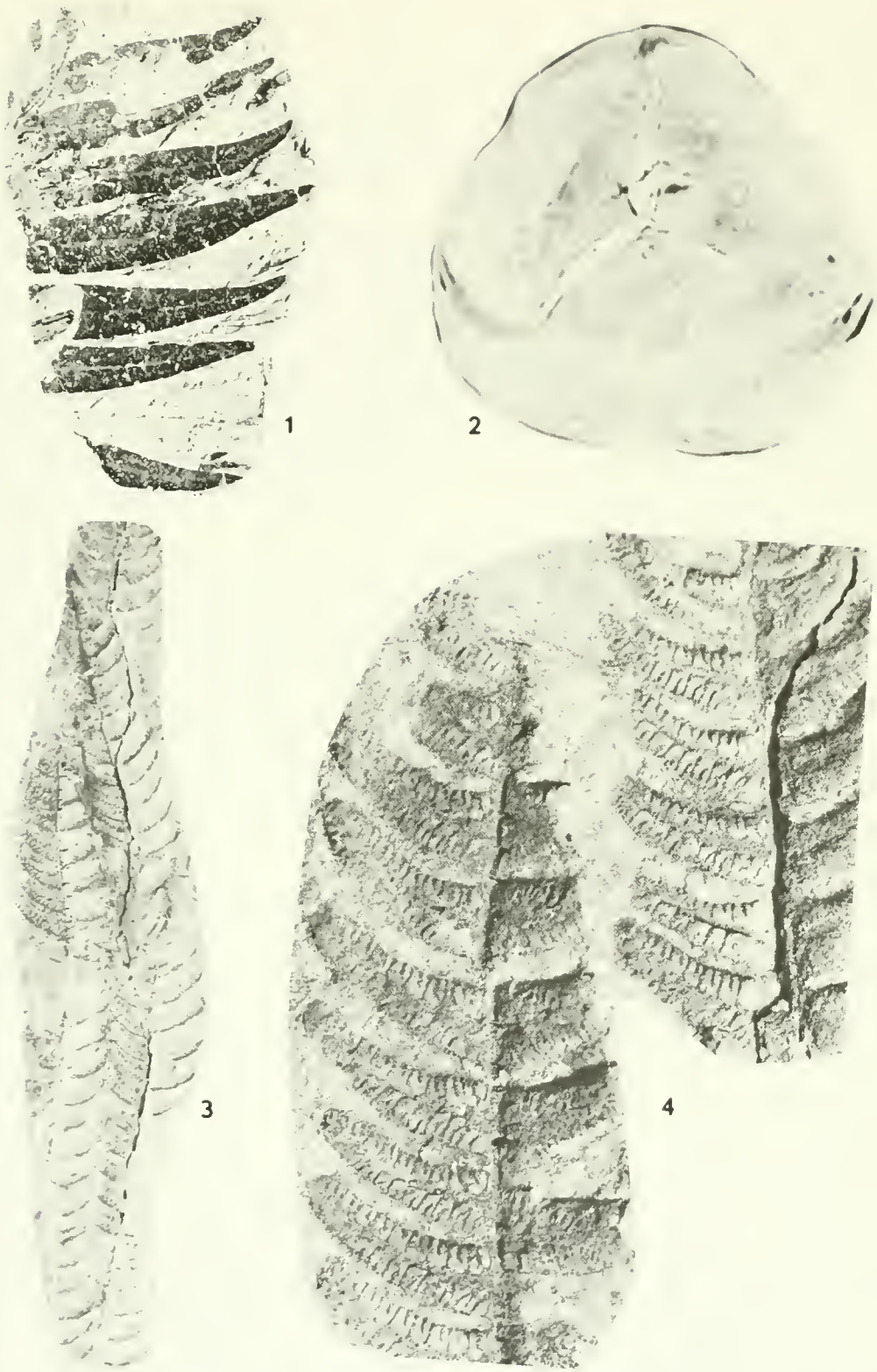

Fig. 18. 1. *Matonidium* (?) *lancipinnulum* Rushforth. Pinna fragment illustrating pinnule disposition. (X1.2). Paratype: BYU 1570. 2. *Matonidium brownii* Rushforth. Trilete spore illustrating weakly defined margo. (X1200). Paratype: BYU 1561. 3. *Matonidium americanum* Berry em. Rushforth. Two pinna fragments. (X1.2). BYU 1572. 4. *Matonidium americanum* Berry em. Rushforth. Portions of two pinnae illustrating venation. (X3.6). BYU 1572.

which when fertile may be placed into several different genera and even families.

Fontaine (1889) treated 23 species and several varieties of *Cladophlebis* from the American Potomac Group. However, Berry (1912) revised this genus, as known from the Potomac, and recognizezd eight speeies. As mentioned by Berry, Fontaine recorded this high number of species:

> . . . altogether losing sight of variation and changes due to age or to position of the fossils with regard to the frond as a whole, as well as changes due to the direct action of the environment.

Seward (1894) in treating Wealden fossils in the Britich Museum of Natural History accepted the generic diagnosis of Schimper (1874) as emended by Fontaine (1889). Berry (1912) also followed this same generic diagnosis, and most workers subsequent to Berry have done likewise.

The literature dealing with *Cladophletbis* is voluminous and is in need of reviewing. Many species are recognized, although this is to be expected in any unnatural genus as reproductive morphology may not be compared. However, many species appear to be identical, and the genus should be monographed.

Cladophlebis constricta Fontaine em. Berry

Figs. 9-5; 11-1.

1889 *Cladophlebis constricta* Fontaine—U.S. Geol. Surv. Mon. 15, p. 68, Pl. 2. Fig. 11; Pl. 3, Fig. 2; Pl. 6, Figs. 5, 6, 8-14; Pl. 21, Figs. 9, 13; Pl. 169, Fig. 2.

1888 *Cladophlebis latifolia* Fontainc—U.S. Geol. Surv. Mon. 15, p. 68, Pl. 3, Fig. 1; Pl. 6, Fig. 4.

1904 *Cladophlebis constricta* Fontaine, in Ward—U.S. Geol. Surv. Mon. 48, p. 197, Pl. 71, Fig. 26.

1905 *Cladophlebis virginensis* Fontaine, pro parte, in Ward—U.S. Geol. Surv. Mon. 48, p. 512, Pl. 111, Fig. 7.

91 *Cladophlebis constricta* Fontaine, Berry—Proc. U.S. Nat. Mus., v. 41, p. 314.

DESCRIPTION.—Entire leaf unknown; pinnules typically greater than 27 mm long by 10 mm wide, margins deeply lobed up to one-half of the distance to the midvein, lobe margins entire, lobe apices obtuse; midvein very strong; secondary veins repeatedly forked, open to the margin; fertile specimens unknown.

OCCURRENCE.—Near Westwater, Grand County, Utah.

REPOSITORY.—Brigham Young University, BYU 1841.

DISCUSSION.—This fern is known from the Westwater flora only from a single specimen. This specimen illustrates fragments of two pinnules each of which is rather well preserved, exhibiting venation well.

This specimen agrees well with some specimens placed by Fontaine (1889) in *Cladophlebis constricta*, especially Pl. 2, Fig. 11a. However, due to the paucity of fossil material from Westwater, it is not known if the Utah specimens agree in all details with the specimens from Virginia. Even though this is the case, venation, overall size, and pinnule lobing, are all in agreement with *C. constricta* Fontaine em. Berry, and the author believes these similarities are sufficient to warrant the placement of the Westwater fern in this species.

Cladophlebis parva Fontaine em. Berry

Figs. 8-5; 11-2.

1889 *Cladophlebis parva* Fontaine—U.S. Geol. Surv. Mon. 15, p. 73, Pl. 4, Fig. 7; Pl. 6, Figs. 1-3.

1899 *Cladophlebis parva* Fontaine, in Ward—U.S. Geol. Surv. 19th Ann. Rept., pt. 2, p. 657, Pl. 160, Fig. 18.

1904 *Cladophlebis parva* Fontaine, in Ward—U.S. Geol. Surv. Mon. 48, p. 125, Pl. 65. Figs. 5-8.

1911 *Cladophlebis parva* Fontaine, Berry—Maryland Geol. Surv., Low. Cret., p. 250, Pl. 27, Figs. 1-2; Pls. 39-31.

1912*Cladophlebis parva* Fontaine, Berry—Proc. U.S. Nat. Mus., v. 41, p. 316.

1956 *Cladophlebis parva* Fontaine, Bell—Geol. Curv. Can. Mem. 285, p. 56, Pl. 11, Figs. 3-5; Pl. 12. Fig. 3; Pl. 13, Figs. 1-2; Pl. 14, Fig. 3; Pl. 14, Fig. 3.

DESCRIPTION.—Entire leaf unknown; pinnae probably lanceolate; rachis about 1 mm in diameter; pinnules alternate, linear-lanceolate, up to 26 mm long by 6 mm wide, lobed approximately one-half of the way to the midrib, margins of lobes slightly undulate, apices acute, attachment basal to somewhat constricted basal; midvein prominent, undivided to pinnule apex; secondary veins divide from one to three times, remain free; fertile specimens unknown.

OCCURRENCE.—Near Westwater, Grand County, Utah.

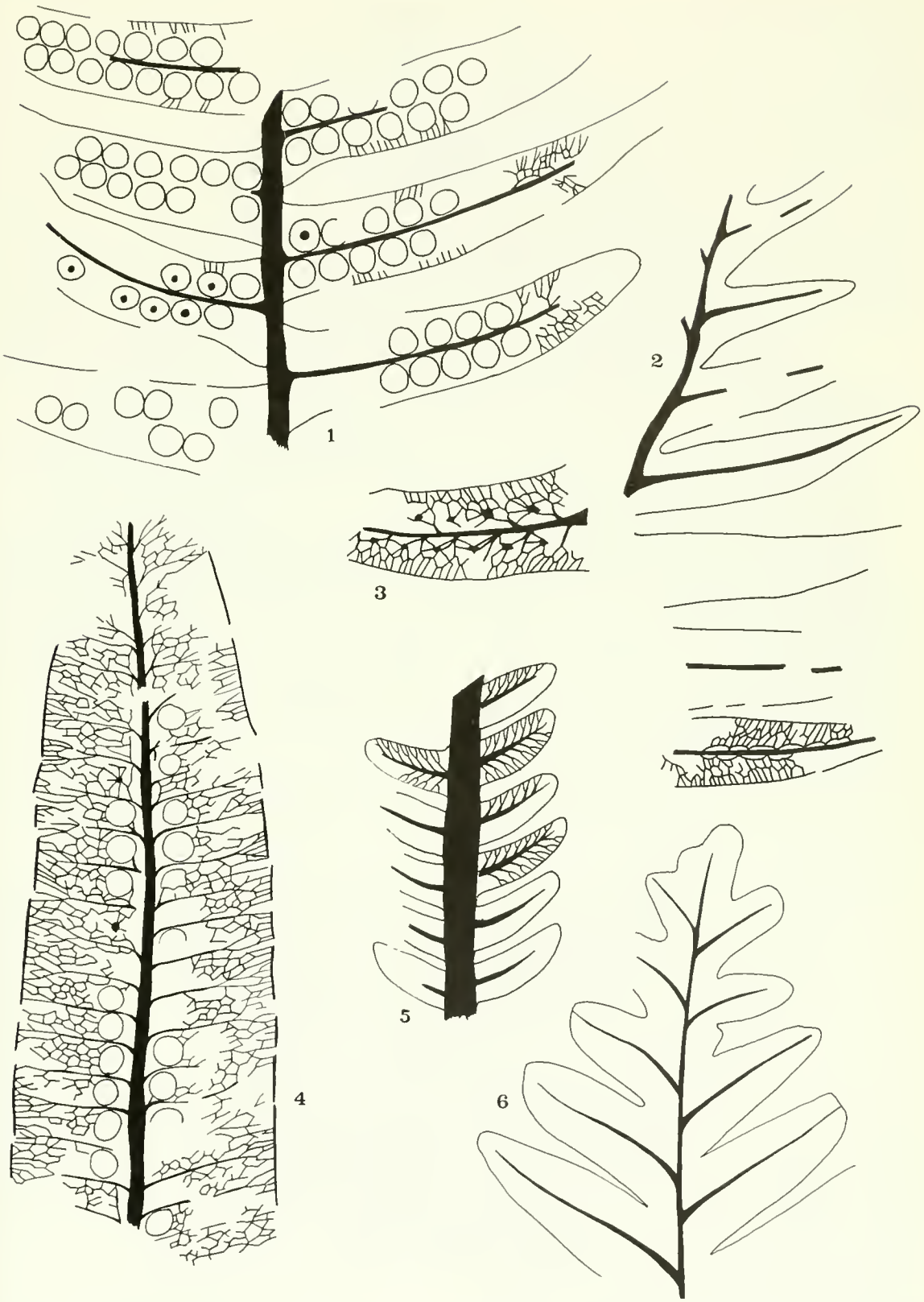

Fig. 19. 1. *Matonidium brownii* Rushforth. Pinna fragment illustrating soriation and venation. (X3). Paratype: BYU 1563. 2. *Matonidium* (?) *lancipinnulum* Rushforth. Pinna fragment illustrating pinnule disposition and venation. Holotype: BYU 1569. 3. *Matonidium brownii* Rushforth. Pinnule exhibiting venation. (X3). Paratype: BYU 1559. 4. *Astralopteris coloradensis* Reveal, Tidwell, and Rushforth. Pinnule exhibiting venation. (X3). BYU 1837. 5. *Matonidium americanum* Berry em. Rushforth. Pinna fragment exhibiting venation. (X3). BYU 1831. 6. *Matonidium brownii* Rushforth. Pinna apex illustrating pinnule disposition. (X3). BYU 1835.

REPOSITORY.—Brigham Young University, BYU 1842.

DISCUSSION.—*Cladophlebis parva* Fontaine em. Berry is known only from one specimen in the Westwater flora. This specimen illustrates several pinnules on a pinna fragment, a few of which are rather complete. This fern from the Westwater locality has been assigned to *Cladophlebis parva* based upon venation, pinnule shape and habit, and size. However, it is always difficult to place fragments of *Cladophlebis* accurately, and this fern resembles several other species of *Cladophlebis*.

Division ANTHOPHYTA (MAGNOLIOPHYTA)

Family AQUIFOLIACEAE

Genus ILEX L.

Ilex serrata Rushforth, sp. nov.

Figs. 12-5; 16-2.

DESCRIPTION.—Leaves vary from fairly short and wide (3.5 cm long by 1.7 cm wide) to longer and thinner (4 cm long by 1 cm wide), somewhat coriaceous, angular-ovate; apex acute to accuminate; base narrowing to the petiole; margins serrate to somewhat spinose; petiole short; midvein weak, continuing to apex; secondary veins mostly obscured, borne at acute angles, progressing to margin.

OCCURRENCE.—Dakota Sandstone Formation near Westwater, Grand County, Utah.

REPOSITORY.—Brigham Young University, holotype: BYU 1801; paratype BYU 1892.

DISCUSSION.—Leaves assigned to this species from near Westwater are somewhat similar to *Ilex dakotensis* Lesquereux in shape and size. However, the leaf originally placed in *I.dakotensis* does not exhibit serrate margins, and venation differs somewhat from Utah specimens. In overall shape, the Westwater material agrees rather closely with *Ilex stenophylla* Unger from the Tertiary of Europe, as does *Ilex dakotensis*. However, Lesquereux (1892) pointed out that these two species differ in size and somewhat in shape. In addition, *I. stenophylla* is not serrate to spinose as is the Utah *Ilex*.

Ilex serrata differs from other species of *Ilex* in its small size coupled with spinose margins. In margination, *I. serrata* is similar to *I. armata* Lesquereux, although the latter is much larger and of different shape than *I. serrata*.

Family MAGNOLIACEAE

Genus MAGNOLIA L.

Magnolia boulayana Lesquereux

Fig. 16-1.

1792 *Maglonia boulayana* Lesquereux—U.S. Geol .Surv. Mon. 17, p. 202, Pl. 60. Fig. 2.

1894 *Magnolia glaucoides* Hollick—Bull. Torrey Got. Club, v. 21, p. 60, Pl. 175, Fig. 1-7.

1895 *Magnolia glaucoides* Hollick, Newberry—U.S. Geol. Surv. Mon. 26, p. 74, Pl. 47, Figs. 1-4.

1995 *Magnolia glaucoides* Hollick—U.S. Geol. Surv. Mon. 50, p. 67, Pl. 19, Fig. 6; Pl. 20, Fig. 6.

1909 *Magnolia boulayana* Lesquereux, Berry—Bull. Torrey Bot. Club, v. 36, p. 254.

1911 *Magnolia boulayana* Lesquereux, Berry—New Jersey Geol. Surv. Bull. 3, p. 131, Pl. 14, Fig. 2.

DESCRIPTION.—Leaf greater than 7.5 cm long by 4 cm wide, narrowly elliptic in outline, coriaceous; base rounded to bluntly rounded; margins entire; midvein strong, bearing somewhat infrequent secondaries; secondary veins pinnate, parallel, progressing to near margin and then beinding to unite with vein above to form rounded areoles near the margin; tertiary veins connecting the secondaries.

OCCURRENCE.—Near Westwater, Grand County, Utah.

REPOSITORY.—Brigham Young University, BYU 1843.

DISCUSSION.—Berry (1911) noted that leaves of *Magnolia boulayana* Lesquereux are remarkably constant in size and shape. This is particularly noteworthy when it is recalled that this constancy extends over wide geographical areas and for a good deal of time.

Berry (1911) noted that leaves assigned to *Magnolia glaucoides* Hollick by Hollick and Newberry are identical to leaves of *M. boulayana*. In view of this, Berry placed *M. glaucoides* in synonomy under *M. bouylayana*.

Placement of the Utah *Magnolia* in *Magnolia boullayana* Lesquereux may be made without hesitation, as size, shape, and venation are all identical between the two.

Family MORACEAE

Genus FICUS L.

This genus in regard to the Mesozoic has become more of a form genus than a natural

Fig. 20. *Astralopteris coloradica* Reveal, Tidwell, and Rushforth. Pinna exhibiting pinnule disposition. (X1.2). BYU 1415.

unit. Into this genus are placed leaves which are somewhat similar in that they exhibit lauraceous characteristics. However, Cretaceous leaves placed in this genus often could be placed with equal logic in various other genera such as *Salix* or *Laurus*.

Ficus daphnogenoides (Heer) Berry

Figs. 16-3, 16-4.

1867 *Proteoides daphnogenoides* Heer, in Capellini and Heer—Denksch. Allgem. Schweiz. Ges. Naturwiss., v. 22, p. 17, Pl. 4, Figs. 9-10.

1874 *Proteoides daphnogenoides* Heer, Lesquereux—U.S. Geol. Surv. Terr. Rept., v. 6, p. 85, Pl. 15, Figs. 1-2.

1905 *Ficus daphnogenoides* (Heer) Berry—Bull. Torrey Bot. Club. v. 32, p.329, Pl. 21.

1921 *Ficus daphnogenoides* (Heer) Berry—U.S. Geol. Surv. Prof. Paper 129, p. 163, Pl. 39, Fig. 1.

1959 *Ficus daphnogenoides* (Heer) Berry, Brown—U.S. Geol. Surv. Prof. Paper221-D, p. 50, Pl. 11, Figs. 1, 2, 4.

DESCRIPTION.—Leaves typically greater than 12 cm long by 3 cm wide, more or less oblanceolate; apex accuminate, forming a rather long drip point; base cuneate; margins entire; midvein strong at point of origin, becoming weaker towards leaf apex; secondary veins pinnate, arising acutely, bending to parallel margin; tertiary veins obscured.

OCCURRENCE.—Near Westwater, Grand County, Utah.

REPOSITORY.—Brigham Young University, BYU 1844-7846.

DISCUSSION.—Lesquereux (1874) described *Proteoides daphnogenoides* Heer (*Ficus daphnogenoides*) as follows:

> Leaves ovate-lanceolate near the base, gradually tapering upward to a long, acute, scythe-shaped point, entire, smooth, and coriaceous; medial nerve narrow; secondary veins obsolete, few, ascending under a very acute angle from the medial nerve and following the borders.

This description fits the Westwater *Ficus* in all respects, and the identity of the two may be fairly certain.

Berry (1905) transferred *Proteoides daphnogenoides* Heer to the genus *Ficus*. This transferral was valid, although Brown (1950) remarked:

> These entire-margined leaves have been referred to many different genera with little satisfaction, as might be expected for entire leaves, the internal venation strucure of which tends in many toward similarity. I regard this reference to *Ficus* as makeshift. Many similar leaves from the Dakota Sandstone have been referred with little evidence to *Andromeda*. All are perhaps examples of lauraceous species that are difficult to separate.

Family MYRTACEAE

Genus EUCALYPTUS L. Herit

Eucalyptus dakotensis Lesquereux

Fig. 15-8.

1892 *Eucalyptus dakotensis* Lesquereux—U.S. Geol. Surv. Mon. 17, p. 137, Pl. 37, Figs. 14-19.

1895 *Eucalyptus angustifolia* Newberry—U.S. Geol. Surv. Mon. 26, p. 111, Pl. 32, Figs. 1, 6, 7.

1895 *Eucalyptus* (?) *nervosa* Newberry—U.S. Geol. Surv. Mon. 26, p. 111, Pl. 32, Figs. 3-5, 8.

DESCRIPTION.—Leaf linear, 4.5 cm long by 1.1 cm wide, somewhat coriaceous; base cuneate; margins entire; midvein strong; secondary veins pinnate, arising obtusely, extending to leaf margin.

OCCURRENCE.—Near Westwater, Grand County, Utah.

REPOSITORY.—Brigham Young University, BYU 1848.

DISCUSSION.—Lesquereux (1892) described *Eucalyptus dakotensis* as follows:

> Leaves coriaceous, linear, or gradually narrowed from an obtuse apex to the base, decurring into short, alate petiole; borders recurved, median nerve strong; secondaries thin, oblique, proximate, parrallel, camptodrome.

Lesquereux further pointed out that the margin of some specimens was flat rather than recurved.

Eucalyptus angustifolia Newberry and *E.* (?) *nervosa* Newberry appear to be specifically identical both with each other and with *E. dakotensis* Lesquereux. The only apparent difference is that the petiole of *E. angustifolia* is naked rather than alate.

The Westwater *Eucalyptus* also agree well with the description of Lesquereux (1892), except that the petiole of the Utah specimen is not winged. However, this difference does not warrant specific separation, and *E. dakotensis* is used for placement of the Westwater specimen.

As mentioned by Lesquereux (1892) *E. dakotensis* differs from an apparently closely related form, *E. geinitzi* in that the former is smaller and linear in shape as opposed to larger and broadly spatulate in shape.

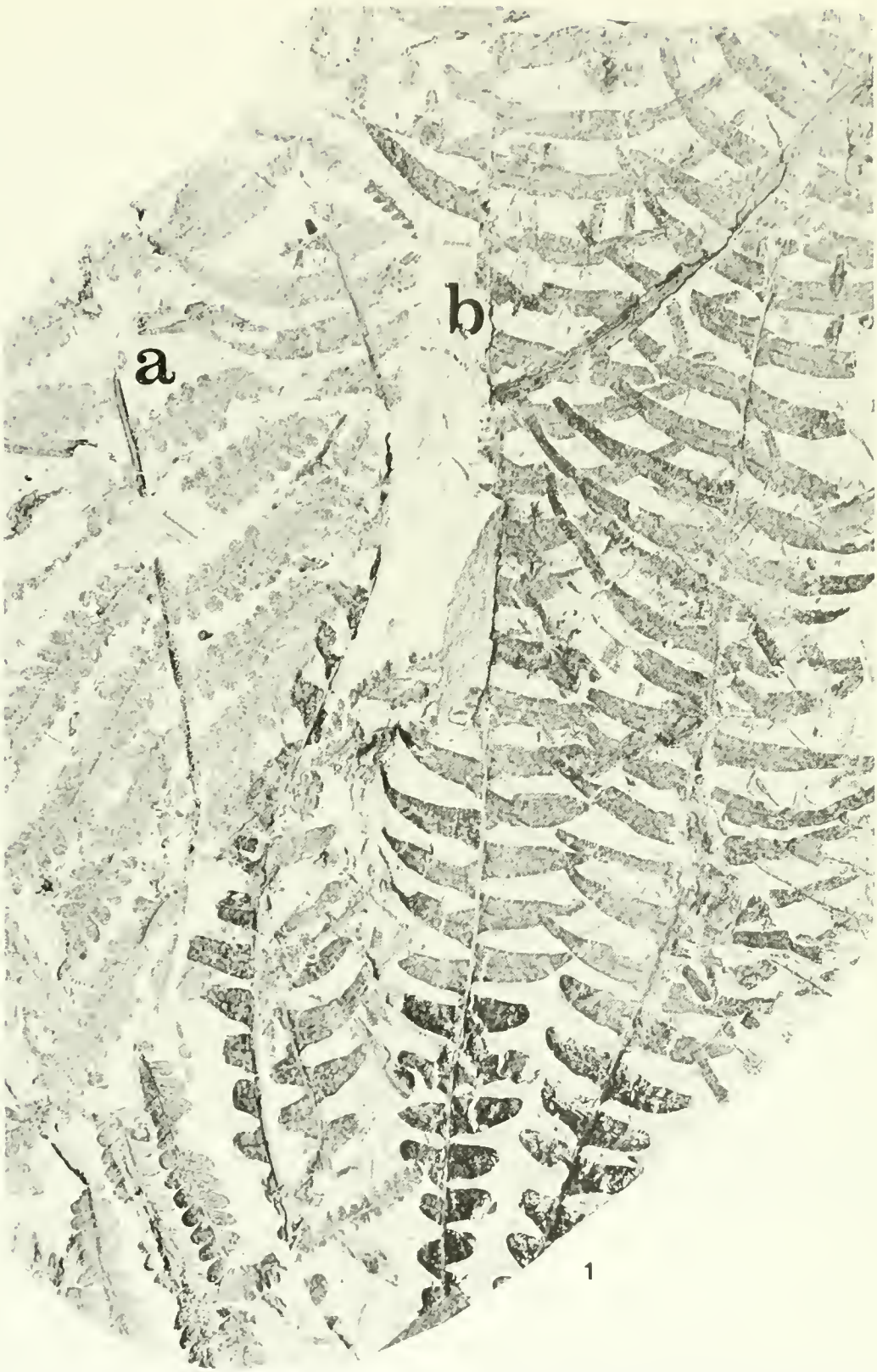

Fig. 21. A. *Gleichenia comptoniaefolia* (Deb. and Ett.) Heer. Pinna fragments exhibiting pinnule disposition. (X1.5). BYU 1853a. B. *Matonidium brownii* var. *magnipinnulum* Rushforth. Pinna fragments. (X1.5). BYU 1853b.

Family PLATANACEAE

Genus PLATANUS L.

Leaves of the genus *Platanus* from the Cretaceous are well known and rather common. Many of these leaves are essentially indistinguishable from those of extant species (Seward, 1827).

Platanus newberryana Heer

Fig. 16-6.

1867 *Platanus newberryana* Heer, in Capellini and Heer–Denksch. Allgem. Schweiz. Ges. Naturwiss., v. 22, p. 16, Pl. 1, Fig. 4.

1868 *Platanus newberryana* Heer. Lesquereux–Amer. Jour. Sci., v. 46, p. 97.

1874 *Platanus newberryana* Heer, Lesquereux–U.S. Geol. Surv. Terr. Rept., v. 6, p. 72, Pl. 8, Figs. 2-3; Pl. 9, Fig. 3.

1874 *Platanus affinis* Lesquereux–U.S. Geol. Surv. Terr. Rept., v. 6, p. 71, Pl. 4, Fig. 4.

1873 *Protophyllum minus* Lesquereux–U.S. Geol. Surv. Terr. Rept., v. 6, p. 194, Pl. 27 Fig. 1.

1874 *Protophyllum nebrascense* Lesquereux–U.S. Geol. Surv. Terr. Rept., v. 6, p. 103, Pl. 27, Fig. 3.

1882 *Platanus affinis* Lesquereux, Heer–Flor. Foss. Arct., v. 6, pt. 2, p. 73, Pl. 18, Figs. 16-17.

1883 *Platanus newberryana* Heer, Lesquereux–U.S. Geol. Surv. Terr. Rept., v. 8, p. 28, Pl. 59, Figs. 1-6; Pl. 60, Fig. 1.

1883 *Cissites affinis* Lesquereux–U.S. Geol. Surv. Terr. Rept., v. 8, p. 67.

1927 *Platanus newberryana* Heer, Seward–Phil. Trans. Roy. Soc. London B, v. 215, p. 128, Pl. 11, Fig. 116; Text-Fig. 30.

DESCRIPTION.–Leaf greater than 5 cm long by 3 cm wide, coriaceous; base rounded; midvein strong bearing numerous secondary veins at acute angles; secondary veins apparently extend to margin (caspedodrome); tertiary veins numerous, borne at nearly 90° angles to secondary veins, connecting secondaries.

OCCURRENCE.–Dakota Sandstone Formation near Rabbit Valley, Grand County, Utah.

REPOSITORY.–Brigham Young University, BYU 1849.

DISCUSSION.–This leaf agrees in all details with *Plantanus newberryana* Heer, and is very similar to leaves figured under this species by Lesquereux and Seward. In addition, it is very similar to leaves described as *Platanus affinis, Protophyllum minus*, and *Protophyllum nebrascense* by Lesquereux (1874, 1882). The Westwater leaf exhibits a rounded to angular base, which agrees with the description of *Platanus newberryana* by Lesquereux (1874), although in this respect it differs somewhat from specimens placed in this species by Seward (1927) which exhibited very rounded bases.

Seward (1927) noted that leaves of *Platanus newberryana* "agree very closely with the recent *Platanus mexicana* Moric."

Family SALICACEAE

Genus SALIX L.

Salix newberryana Hollick

Figs. 12-4; 15-7.

1895 *Salix newberryana* Hollick, in Newberry–U.S. Geol. Surv. Mon. 26, p. 68, Pl. 14, Figs. 1-7. 1911 *Salix newberryana* Hollick, Berry–New Jersey Geol. Surv. Bull. 3, p. 113, Pl. 11, Fig. 2.

DESCRIPTION.–Leaves greater than 6 cm long by up to 2.5 cm wide, lanceolate; base rounded; apex accuminate to form a rather well defined drip point; margins finely crenate to dentate; midvein fairly strong; other veins obscure.

OCCURRENCE.–Dakota Sandstone Formation near Westwater, Grand County, Utah.

REPOSITORY.–Brigham Young University, BYU 1850-1851.

DISCUSSION.–This leaf from Westwater is essentially identical to those described by Hollick (in Newberry, 1895) and Berry (1911). It may be placed with confidence in *Salix newberryana* Hollick.

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BOTANICAL AND PHYSIOGRAPHIC RECONNAISSANCE OF NORTHERN BRITISH COLUMBIA

by

Stanley L. Welsh

and

J. Keith Rigby

BIOLOGICAL SERIES — VOLUME XIV, NUMBER 4

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FRONTISPIECE. *Picea glauca* woods along the Narrows of the Grand Canyon of the Stikine River, approximately 35 miles upstream from Telegraph Creek, British Columbia. In this section the Stikine River has cut a spectacular gorge up to 1000 feet deep through horizontal Tertiary rocks and underlying steeply folded Triassic and Upper Paleozoic rocks. The river has an elevation of approximately 1500 feet here at approximately 58°08′ N; 130°20′ W.

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TABLE OF CONTENTS

	Page
INTRODUCTION	1
Location	1
Accessibility	1
PHYSICAL FEATURES	6
VEGETATION	12
Boreal forest	12
Alpine tundra	14
COLLECTING LOCALITIES	15
ANNOTATED LIST OF SPECIES	19
REFERENCES	49

BOTANICAL AND PHYSIOGRAPHIC RECONNAISSANCE OF NORTHERN BRITISH COLUMBIA

by

Stanley L. Welsh[1] and J. Keith Rigby[2]

ABSTRACT

The area of study is located in northern central British Columbia and includes the Sustut Basin and surrounding mountains. The physiography and geology of the region is described and the plant communities are enumerated. An annotated list of 205 species, 11 subspecies, and 35 varieties collected during the summer of 1969 is included.

INTRODUCTION

Location

The Sustut Basin and surrounding mountains, the primary area of collecting, are located in north central British Columbia (Fig. 1) in parts of the McConnell Creek, Spatsizi, Toodoggone, Dease Lake, and Cry Lake quadrangles. The collecting area, approximately 150 miles long and 40 to 50 miles wide, extends northward from approximately 56°39′ to 58°30′ North latitude, and westward from 126°30′ to 130°30′ West longitude. Collections are representative of the region between Thutade Lake and Sustut Peak, northwestward to Dease Lake, in a belt northeast of the Skeena River and Little Klappan River valleys and southwest of the Omineca and Thudaka Ranges in the headwaters of the Stikine, Finlay, and Skeena Rivers (Fig. 2).

Prince George is 279 miles southeast of the southern part of the basin and Hazelton is 120 miles to the south-southwest (Fig. 1). Telegraph Creek is 99 miles northwest, and Watson Lake, Yukon, is 135 miles north of the northern part of the area.

The Sustut Basin is situated along the Continental Divide between Arctic and Pacific drainages. Much of the southern part of the basin drains through the Finlay River into the Peace River and the Arctic Mackenzie drainage. The southwestern part drains into the Skeena River, and the central and northwestern part drains into the Stikine River in the Pacific drainage. The Kechika and Dease Rivers drain the north and northeastern area into the Liard River and Arctic drainage.

Accessibility

The area of primary concern is currently accessible only by float planes to the several lakes in the area and by helicopter. Even large planes can work from Thutade, Tatlatui, Trygve, Kitchener, Cold Fish, and Dease Lakes (Fig. 2). Several of the smaller lakes are adequate for landing by either a Beaver or Otter and could function as a secondary campsite or base. A short, graded but unsurfaced, air strip is available at the southeastern corner of the area in the vicinity of Sustut Peak and Moose Valley. The strip is currently maintained by the New Wellington mine operation and is capable of handling a Twin Beechcraft, although at certain times of the year the strip is soft. A second dirt strip is maintained at Hyland Post, in the central part of the area, on the Spatsizi River. A third was contemplated by 1970 at the northern end of Cold Fish Lake in the northwestern part of the basin.

Although no roads lead directly into the area, several roads are constructed into relatively nearby areas. An all-weather, maintained, graded road leads from Watson Lake and the Alaska Highway south to Dease Lake and southwest to Telegraph Creek. A spur road is currently under construction which will connect Dease Lake and Stewart. This road is finished as far south as

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Kinaskan Lake and could be utilized by field vehicles as far as Bob Quinn Lake in 1969. A winter caterpillar tractor trail is developed eastward from Dease Lake approximately 20 miles in the vicinity of the east side of Dome Mountain and could afford access to the northern part of the area. A mine access road along the north side of the Stikine River was under construction late in the summer of 1969. It extends east from near the Stikine River ferry to the southeastern margin of the Three Sisters Peaks region, near the northern edge of the Sustut Basin.

Topographic maps with a scale of 1:250,000 are available for the entire area. Relatively recent geologic maps are available for the eastern half of the McConnell Creek Quadrangle (Lord,

FIG. 1. Map of British Columbia showing area of collection.

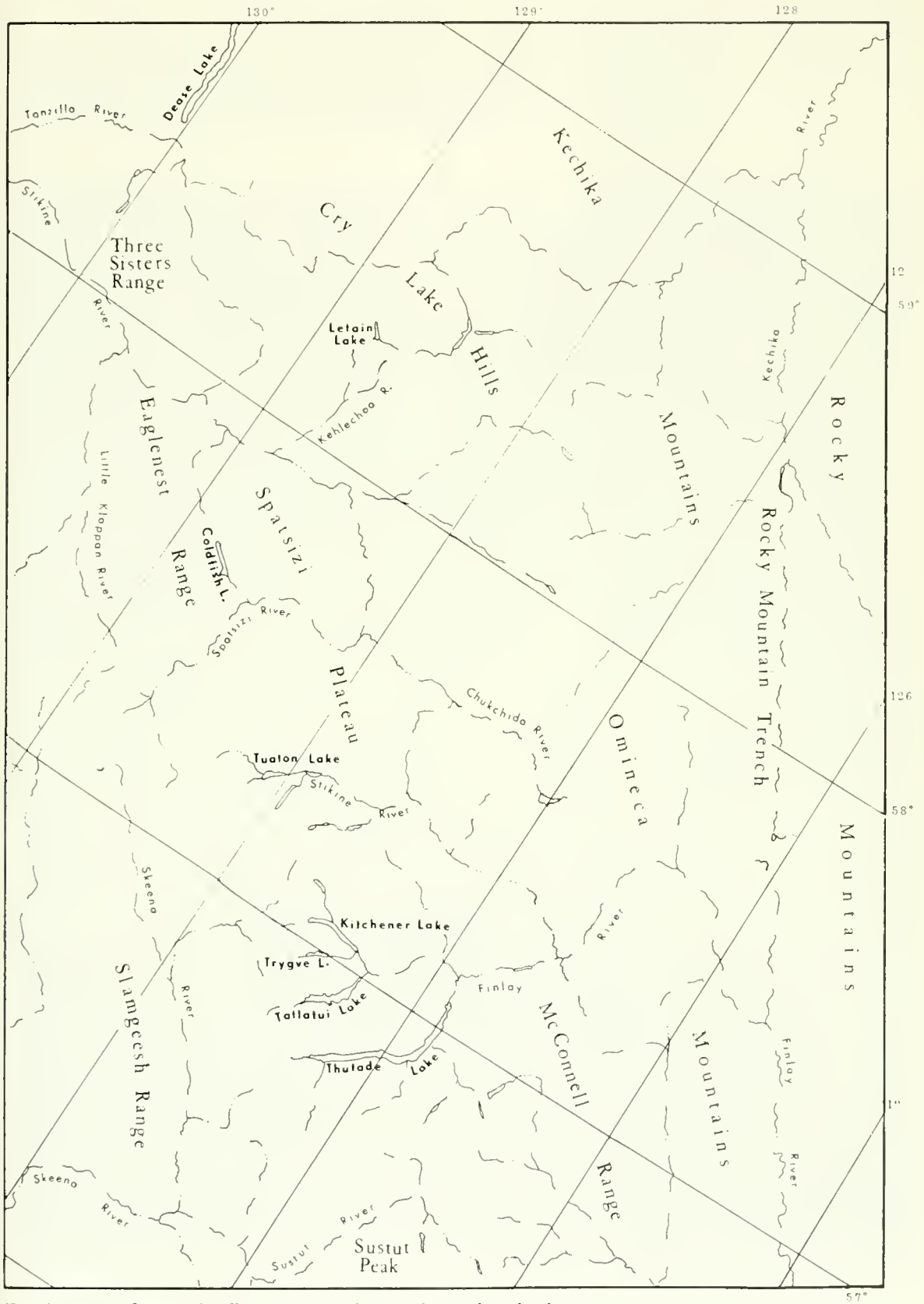
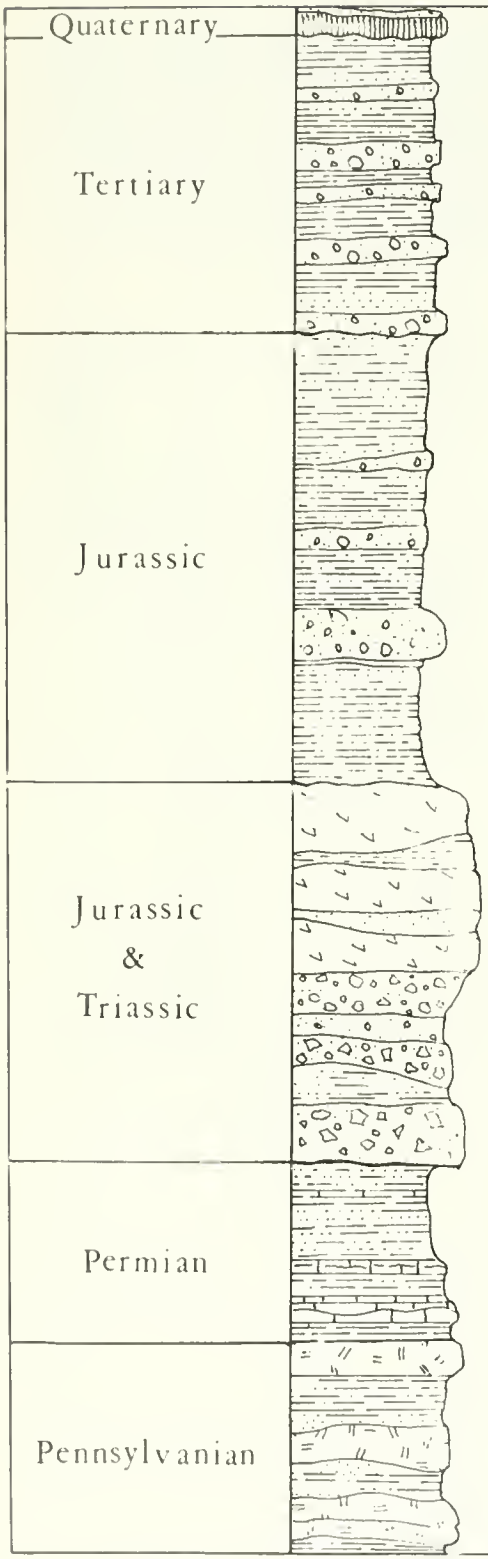


Fig. 2. Map of area of collection, in north central British Columbia.



TUYA BASALT and overlying glacial debris and alluvium

SUSTUT GROUP

Well-bedded sandstone, conglomerate, mudstone with minor interbedded dacite tuff, carbonaceous shale and coal. Group may include some Cretaceous rocks in the lower part. Generally well-bedded and flat lying in plateaus, with ledges and slopes.

BOWSER GROUP

Interbedded gray-green and dark-gray, thin-bedded mudstone and siltstone, gray-green, thin- to thick-bedded graywacke sandstone, massive to thick-bedded graywacke pebble- to cobble-conglomerate, with minor thin limestone, coal, and carbonaceous shale units.

TAKLA GROUP

Massive gray-green, reddish brown, and maroon agglomerate with local beds of graywacke and tuff with minor siliceous and tuffaceous argillite and basalt. Forms resistant crags and cliffs in higher ranges of the region.

CACHE CREEK GROUP

Interbedded chert, graywacke, tuff, basalt, and limestone in somewhat cyclic sequence. Limestones are locally fossiliferous and cherty; graywacke and tuff units are siliceous. Entire unit shows some metamorphism and structural complexity. Forms shoulders below crags of Triassic volcanic section.

ASITKA GROUP

Reddish brown, pinkish gray and bright apple green tuff and argillite with interbedded massive pinkish brown to maroon rhyolite and andesite flows. Forms craggy exposures near the valley margins.

FIG. 3. Geological section for northern British Columbia.

1948), and Cry Lake Quadrangle (Gabrielse, 1962) and the Dease Lake Quadrangle (Gabrielse and Souther, 1961). The Spatsizi and Bowser Lake quadrangles are covered as part of the older Project Stikine map by the Geological Survey of Canada (1957). Aerial photographs, with a scale of approximately 1:30,000 are available for most of the area of primary concern through offices of the Geological Survey of Canada in Calgary.

Fig. 4. Geological camp at Coldfish Lake, on beach gravel of high stand of the lake, in a protected forest at collecting locality 6, at approximately 57°39′ N; 128°44′ W, at an elevation of approximately 3820 feet. Mixed woodland dominated by *Pinus contorta, Picea glauca,* and *Betula glandulosa.*

PHYSICAL FEATURES

All of the collecting area is included in the Interior Ranges of British Columbia and in the Interior Plateau section in the Stikine River region along the east side of the Bowser Basin, 60 miles southwest of the Rocky Mountain Trench. In broad terms the entire region can be subdivided into: 1) the high rugged topography of the Sustut belt; 2) the low bordering lowland river valleys along the southwestern, northern and northeastern sides of the plateaus; 3) the horizontally bedded plateau belt from Thutade Lake northwestward into the Spatsizi Plateau; 4) folded Sustut and Bowser beds and the intensely folded high mountains and glaciated areas east of the Skeena River Valley; 5) the Cry Lake hills to the north; 6) the uplands and highlands to the northeast of the basin; 7) the Eaglenest Range uplands; and 8) Three Sisters Range.

The Sustut Peak highlands and adjacent Asitka uplands are a region of relatively mountainous terrain that extends from Niven Peak southeast beyond Sustut Peak in the region of outcropping Paleozoic and Triassic to upper Jurassic volcanic rocks (Lord, 1948). The belt of highlands is dominated by Sustut Peak which rises to an elevation of 8100 feet, 4000 feet above the valley floor of Moose Valley on the northeast and Sustut Lake directly to the east. Savage Peak, with an elevation of 7600 feet, and Dewar Peak, with an elevation of 7350 feet, are northern parts of the highlands. All of the major high peaks are horns and are connected to one another by arête ridges. The entire area has been intensely glaciated, and active glaciers still persist on the northeast side of Savage and Dewar Peaks and around the east and north sides of Sustut Peak. The eastern part of the range is carved in large part from folded Late Paleozoic volcanic and carbonate rocks that produce a relatively subdued topography in contrast to the high peaks

FIG. 5. Forest in the vicinity of the Cold Fish Lake camp, Locality 6, at 57°39′ N; 128°44′ W, at approximately 3800 feet elevation. Boreal forest of *Pinus contorta* and *Picea glauca*, with tents surrounded by *Salix* species and *Betula glandulosa*.

Fig. 6. West across Coldfish Lake from the campsite at 57°39′ N; 128°44′ W. toward the south end of the Eaglenest Range, with well-developed Boreal Forest in the foreground and along the low flanks of the volcanic range in the background. The camp is at approximately 3800 feet and the range crest at approximately 7500 feet. Boreal Forest of *Picea glauca, Abies lasiocarpa,* and *Pinus contorta.* The lake shore is fringed with *Betula glandulosa* and *Salix* species.

and ragged massive cliffs carved on the thick-bedded Triassic and Jurassic agglomerate along the west side of the belt. Toward the northwest Sustut Peak highlands are separated from the southeastern plateaus by the broad Niven River valley which separates the folded Paleozoic Triassic and Jurassic rocks from the nearly flat-lying Cretaceous and Tertiary Sustut rocks to the northwest (Fig. 3). Broad Moose Valley and Asitka River valley on the east separate the Sustut Peak area from the McConnell Range and other mountainous areas of the Omineca batholithic areas to the northwest.

Broad flat-topped, but deeply indented, glaciated plateaus have developed along the northeastern side of Sustut Basin from near Thutade Lake, northwestward beyond the Spatsizi Plateau, to the Stikine Valley in the vicinity of the

Three Sisters Range, a distance of approximately 100 miles. The plateau section is carved on horizontal or very nearly horizontal Sustut beds which form relatively open, simple-contoured topography and extends from Mt. Forest-Niven River region southeast of Thutade Lake northwestward across the entire Spatsizi Plateau. The characteristic topographic development of the horizontal beds is perhaps best shown in the area between Tatlatui and Thutade Lakes in the

FIG. 7. Southwest along Buckinghorse Creek near its junction with the Spatsizi River. Outcrops of Jurassic volcanics are in the foreground with spruce woods on the talus of the overlying Bowser formation at approximately 57°27' N; 128°35' W. *Picea glauca* woodland, with *Populus tremuloides*, *Betula glandulosa*, and *Salix* species in the openings.

vicinity of Tabletop Mountain and Mt. Jorgensen (Fig. 25) where the alternating resistant and nonresistant beds form almost lake terracelike topographic features. The same erosional pattern can be seen from southeast of Thutade Lake on Thutade Peak and on Mt. Forest and to the Stikine River Valley and Idozadelly Mountain and the Spatsizi Plateau in the bend of the Stikine River. The entire flat upland of the plateau rises to an elevation of 6500 to 6800 feet, approximately 3000 to 4000 feet above the valley floor lowlands. It is a region of broad open summits and relatively gently sloping walls to broad, flat, river valleys. In general, it is a region where lake development is not extensive. The northeastern tip of Thutade, Tatlatui, Kitchener and Laslui Lakes extend into the western part of the plateaus, but broad valleys of these lakes and their drainages dissect the plateau surface.

An eastern lowland belt separates the horizontal plateau section, where Tertiary and Cretaceous horizontal rocks dominate, from the dipping Triassic and Jurassic rocks along the flanks of the Omineca and Cassiar batholith belt to the east and northeast. A nearly continuous, low, broad valley extends southeast from near Dease Lake along tributaries and main valley of the Stikine River into the vicinity of Caribou Hide, and then on the Toodoggone River and continuing southeastward into the headwaters of the Finlay River and Moose Valley. These broad, low valleys have an elevation of from 3000 to 4500 and range up to 15 to 20 miles wide. The various drainages are separated by low, broad passes such as Matzantan Pass between the Toodoggone and Stikine rivers; Lawyer's Pass between the Toodoggone and Chapea rivers, the latter a tributary near the head of the Finlay River at Thutade Lake. A broad pass in the middle of Moose Valley separates the Finlay River drainage from that of the Skeena and the Sustut Rivers and is almost unnoticed when flying over the region in the southwestern end of the valley.

A western lowland along the Klappan and the Little Klappan and the Skeena rivers continues N 30° W, almost along strike near the south-

Fig. 8. Boreal Forest on the north flank of the deep Grand Canyon of the Stikine River at approximately 58°09′ N; 130°21′ W, above the junction of the Tanzilla River with the Stikine River. Prominent ledges are of conglomeratic sandstone separated by broad shale belts along the shoulder of the canyon at an elevation of approximately 2500 feet. Mixed *Picea glauca-Populus tremuloides* woodland.

FIG. 9. Northwest toward the main massif of Savage Peak, elevation 7600, at 56°39′ N; 126°42′ W, eroded from massive agglomerate of the lower part of the Takla Group. The rocks which hold up Savage Peak are essentially of the same unit as that which holds up Sustut Peak to the southeast. Savage Peak is here proposed for Douglas Savage who has spent many years in the area and who was killed in a helicopter crash just east of the peak in Moose Valley in the summer of 1969. Valley bottom with meadow and Boreal Forest extending up slope to alpine tundra.

western border of the area of primary concern. These valleys are 4 to 5 miles wide, broad, with steep walls and are intensely glaciated. They separate the interior of the Bowser Basin from the folded Bowser beds to the northeast. Both the Skeena and Klappan valleys have elevations between 3000 and 4000 feet and bridge over a broad open pass at almost midlength along the area of concern near Mt. Gunnanoot. The Skeena River drains to the southwest into the Pacific, and the Klappan and Little Klappan River drain ultimately into the Stikine River near the northwestern edge of the acreage and then into the Pacific.

West and south of the horizontally bedded plateaus of the Sustut Basin is a mountainous area carved, in large part, in complexly folded and faulted Jurassic Bowser Group and Creta-

ceous Tertiary Sustut beds. The boundary between these folded rocks and the relatively simple to horizontal Sustut beds of the basin is along a prominent hogback or a line almost due northwest from the middle of Thutade Lake, northwest across the tip of Tatlatui and Kitchener lakes, along the west base of the Brothers Peak and northwest across Lashui Lake toward the western Spatsizi Plateau east of Coldfish Lake. Southwest of this hogback both the Bowser and Sustut rocks are complexly folded in a series of asymmetric anticlines and synclines. The folded beds and the relatively high elevation produce rather spectacular, sharp, serrated peaks, many of which are now glaciated, characterized by such heights as Rama Peak, with an elevation of 7105 feet, Chipmunk Peak with an elevation of approximately 7135 feet, and Mellanistic Peak, with an elevation of 7110 feet. All of these rise 4000 to 4500 feet above the general low valley along the Skeena River to the west and above the general elevation of 6000 to 6500 feet of the plateau regions to the northeast.

Three Sisters Range is a complex igneous intrusive mass in Triassic and Jurassic volcanic rocks. It occurs near the northwest border of the area a few miles southeast of Dease Lake. In this general area the rock dip regularly from the intrusive mass near the Three Sisters Peak into the low country along the southeast border of Dease Lake and south and eastward into the Stikine River Valley and its tributaries. Peaks in the range rise to 7565 feet in the northeastern part. Three Sisters Range is nearly circular, 15 to 20 miles in diameter, and is the southwesternmost major promontory of igneous activity associated with the Omineca-Cassiar batholith sequence. The Three Sisters rises above the McBride River hills to the east and the Hotailuh Range to the west. These latter areas are of relatively moderate relief and are in folded Triassic rocks, in the main.

Fig. 10. Meadow, shrubland, and Boreal Forest along Spatsizi Valley, at lat. 57°34′ N. long. 128°33′ W, elevation 3700′.

The Eaglenest Range highland is carved in folded Jurassic (?) volcanic rocks but is distinctive from less prominent peaks carved in the folded Jurassic Bowser beds because of the spectacular, sharp, serrated ridges and peaks which the massive volcanic rocks have produced. The Eaglenest Range rises above broad Coldfish Valley, which separates it from the Spatsizi Plateau, to the northwest, and generally above the ranges of folded Bowser rocks to the west and southwest. Like other ranges, glaciated valleys are often connected by low passes through the margin of the range or near the valley floor of adjacent lowlands. Peaks, such as Nation Peak, with an elevation of 7741 feet; Mt. Will, with an elevation of approximately 7600 feet, and Cartmell Mountain, with an elevation of 7135 feet, rise three to four thousand feet above adjacent valleys.

Cry Lake Hills, at the northern margin of the area studied, are carved in metamorphosed Paleozoic and Mesozoic rocks and form rather subdued to rounded ranges and hills, all of which have been glaciated and rounded beneath ice masses (Gabrielse, 1962). The Cry Lake Hills are relatively low features, with a relief of approximately 2000 feet in the main, and occur in front of the main Stikine Ranges to the northeast in the belt of Omineca and Cassiar batholith development. These hills are more or less topographic continuations of the Mt. Dease and the McConnell Range uplands which rise only moderately above the bordering Stikine River-Sturdee River-Moose Valley lowlands. The Cry Lake Hills and the other southeastward continuations show on the topographic maps as generally rounded topography rather than as sharply ridged and jagged topography of adjacent highlands to the northeast.

VEGETATION

Boreal Forest

The Boreal Forest, which occupies most of the area of northern British Columbia, is dominated by three tree species (Figs. 4, 5, and 6). The most abundant of these is the white spruce, *Picea glauca.* Next in importance is the alpine fir, *Abies lasiocarpa.* Third in importance numerically is the lodgepole pine, *Pinus contorto.* There are two other tree species which make up a smaller part of the total Boreal Forest. They are the aspen, *Populus tremuloides,* and the cottonwood, *P. balsamifera.* White spruce is abundant on alluvial gravels in valley bottoms, and on glacial moraine and talus. Alpine fir occurs as individual trees and in small groups within the spruce-dominated woods in the lower elevations. Upwards, the alpine fir is more abundant, and in timberline situations alpine fir is the dominant conifer. Lodgepole pine occurs mostly on ridges of glacial moraine, which are evidently better drained than the surrounding regions. In some sites, such as north of New Wellington mining camp, lodgepole pine occur in almost pure stands.

Aspen occurs in parkland areas, usually above the spruce forest, but also in openings in spruce woodlands, commonly on slopes (Figs. 7 and 8).

Major components in the understory of the spruce-fir-pine woods include species of willow (*Salix* spp.), and the almost omnipresent dwarf birch, *Betula glandulosa.* Other components of the understory include:

Linnaea borealis, Viburnum edule, Shepherdia canadensis, Lonicera involucrata, Cornus canadensis, and *Empetrum nigrum.*

The ground layer in the woodlands consists of sparse to dense vegetation. In some areas there are three species of violet growing sympatrieally, two of which are common (*Viola adunca, V. glabella*) and one uncommon (*V. unifolia*). Other plants in the ground layer include:

Lycopodium annotinum, Lycopodium complanatum, Lycopodium alpinum, Equisetum arvense, Anemone richardsonii, and *Listera cordata.*

During the second week of June 1969, the spores were released from *Lycopodium annotinum* in large numbers. Spores covered the entire surface of Thutade Lake. Wind and water currents concentrated the spores into long yellowish streamers on the lake surface, and finally onshore breezes stacked windrows of spores along the lake shore. Some of the windrows were to one-half an inch in depth.

Parkland meadows are present in valley bottoms in the Boreal Forest. Willows and dwarf birch grow along the drainages in the meadowlands (Figs. 9 and 10). The meadows proper are occupied in wet sites by the cottongrass, *Eriophorum angustifolium,* and the sedge, *Carex aquatilis.* Drier sites in the meadows are dominated by species of *Poa, Festuca altaica,* and *Calamagrostis purpurascens.*

Fig. 11. Steep monocline and flat-lying portion of the middle and upper part of the Sustut Formation 4 miles northwest of Thutade Lake at approximately 56°53′ N; 127°11′ W. Resistant beds are conglomerate and separated by thick units of softer silty mudstone and shale.

Riparian and Palustrine vegetation consists of essentially the same species which occur in the Boreal Forest. However, on alluvial gravels along stream courses the cottonwoods (*Populus balsamifera*) and willows (*Salix* spp.) and alder (*Alnus crispa*) become more dominant.

A steep south-facing slope about two miles southwest of the southern end of Thutade Lake is worthy of mention. This region is occupied by up and down slope stripes of trees which alternate with similarly oriented stripes dominated by herbs and shrubs. The herb and shrub stripes are apparently due to snow slides which sweep away tree growth and allow herbs and shrubs to dominate. On June 14 at about 8:00 p.m., we landed the helicopter on a small outcrop in one of the slide areas, and in about an hour we were able to collect some 39 species. The shrubby vegetation consists of *Viburnum edule*, *Ribes glandulosum*, and *Sambucus racemosa*. Important herbaceous species include: *Valeriana sitchensis*, *Aquilegia formosa*, *Heracleum lanatum*, *Hackelia jessicae*, *Geranium erianthum*, *Senecio triangularis*, *Castilleja unalaschcensis*, *Veratrum eschscholtzii*, *Myosotis sylvatica*, *Pedicularis bracteosa*, *Lupinus nootkatensis*, and *Urtica dioica*.

Principal grasses on the slope include species of *Poa* and *Festuca altaica*. The habitat and species list is reminiscent of open slopes in Little Susitna Canyon in south central Alaska.

The upper elevational limit of the Boreal Forest varies considerably, but most of the forest occurs below the 5,000 foot line. However, there are trees growing to about the 6,000 foot line in some regions. In these sites, the trees occur singly, in small clumps, or in long lines trending upward along drainages or slopes (Figs. 11 and 12). In other sites the tree line is truncated along the apparent upper limit of glacier ice of the Pleistocene glaciation (Figs. 13 and 14). The forest is best developed on glacial debris

along the slopes and on moraines and alluvium in the valleys. The tree species above about 5000 feet in elevation are limited to spruce and alpine fir. The trees take on a krummholz appearance, spreading out horizontally along the slopes above the tree phases more typical of the forest at lower elevation (Figs. 15 and 16). The krummholz type occurs in patches to several acres in extent, mostly above areas affected by glacier ice, and it seems probable that some of these may have persisted throughout the Pleistocene glaciation and have provided propagules for reforestation of the valleys following the retreat of glaciers. The krummholz interfingers upwards with alpine tundra (Figs. 17, 18, 19, and 20). In its upper limits, the alpine fir krummholz grows with *Phyllodoce empetriformis*, *P. glanduliflora*, and *Cassiope tetragona*.

Alpine Tundra

Alpine tundra is well developed in the mountains of northern British Columbia. On alpine slopes and rounded ridge tops the tundra is dominated by *Dryas integrifolia*, *Festuca altaica*, *Carex* sp., *Cassiope tetragona*, *Salix arctica*, *S. glauca*, *S. reticulata*, and *S. stolonifera* (Figs. 21, 22, 23, 24, and 25). On ridges, beginning at about 6000 feet elevation, and steep slopes upwards from that elevation, the tundra consists of sparse vegetation, dominated by clumps of *Dryas integrifolia*, *Potentilla diversifolia*, *P. hyparctica*, *P. uniflora*, *Lupinus arcticus*, *Oxytropis campestris*, *Luzula confusa*, *L. nivalis*, and *Carex* sp. (Figs. 26, 27, and 28). In some areas the bearberry, *Arctostaphylos alpina* is present near the upper limits of alpine tundra. Between 6000 and 7000 feet elevation, the open spaces between plants on rock outcrops and rocky ridge crests, crustose lichens form the most abundant plant cover (Figs. 29, 30, 31). These semibarren lichen dominated lands are herein called fell fields. Important species of flowering plants in fell fields include:

Ranunculus eschscholtzii, *Potentilla diversifolia*, *P. hyparctica*, *Sibbaldia procumbens*, *Hierochloe alpina*, *Pedicularis sudetica*, *Anten-*

FIG. 12. Northwest to the northeast spur of Sustut Peak at 56°37′ N, 126°35′ W. The relatively smooth, even crestline of the ridge is in the sandstone sequence near the base of the Triassic Takla Group. The deep snow-filled col near the right margin is at the approximate boundary between Triassic and Permian rocks. The ridge crest is at an elevation of approximately 7000 feet. Alpine tundra grading downward with krummholz and Boreal Forest.

naria monocephala, *Antennaria alpina*, and *Salix glauca*.

A particularly inhospitable habitat was encountered on an outcrop of siltstone and coal beds in a saddle about 5 miles southeast of the south end of Thutade Lake (Fig. 32). The surface is in large part barren of vegetation, but plants, *Draba incerta* and *Carex podocarpa*, occur widely spaced on the soft surface. This is the only locality wherein *Arenaria sajanensis* was collected, growing directly on the carbonaceous surface.

COLLECTING LOCALITIES

Plants were collected at localities throughout the Sustut Basin during much of the growing season (Fig. 33). Collecting was initiated on June 7 and the final collections for the season were taken on August 13. All major plant communities were sampled, but the list of specimens

Fig. 13. Dewar Peak at 56°43′ N., 126°50′ W. as seen from the southeast. Dewar Peak is composed of pinkish gray rhyolite and andesite in the upper part of the Asitka Group which also forms the ragged rocky exposures on the skyline to the right. Locality 34 is in the prominent saddle on the skyline to the immediate left of Dewar Peak and is at an elevation of approximately 6400 feet. Woodland dominated by *Picea glauca* and *Abies lasiocarpa* grading upwards with krummholz of *Abies lasiocarpa* and alpine tundra and fell fields.

FIG. 14. Southwest across Coldfish Lake Valley to the prominent serrated massive volcanic rocks of the Eaglenest Range. The snow line is at about the upper level of the Boreal Forest. The snow is from the early snowstorms which came the 10th to 12th of August and blanketed the uplands. The snow line corresponds with the approximate upper limit of trees and to near the elevation of maximum elevation of valley glaciers during major Pleistocene glaciations.

collected is not represented as being exhaustive for the region. Many additional species will undoubtedly be added as the flora of this magnificent region becomes better known. The nature of the Sustut Basin can be seen from the aerial photographs of selected areas (Figs. 34-42).

1. Ironbridge. South bank of the Tanzilla River, 8 miles south of Dease Lake village, at Ironbridge, along Dease Lake-Stewart Highway, 58°21′ N; 129°52′ W, at 3090 feet elevation, on river terrace gravels.
2. Letain Lake. Asbestos prospect, northeast of Letain Lake, and ca 7 miles west of King Mt., at 58°20′ N; 128°45′ W, at 6000 feet elevation, in Alpine tundra, on weathered serpentine intrusive.
3. Kehlechoa River. Ridge west of Kehechoa River, at 58°12′ N; 128°45′ W, at 5000 feet elevation, in alpine tundra, on green micaceous schists.
4. Cold Fish Lake, north shore. North end of Cold Fish Lake, at 57°42′ N; 127°50′ W, at 3800 feet elevation, in Boreal Forest, on glacial moraine.
5. Cold Fish Lake, camp ridge. Cold Fish Lake, south end of camp ridge, at 57°40′ N; 128°45′ W, at 3800 feet elevation, in open woods on glacial moraine.
6. Cold Fish Lake. South end of Cold Fish Lake, at 57°34′ N; 128°44′ W, at 3800 feet elevation, in Boreal Forest, on glacial moraine and beach gravel.
7. Chukachida River. South of the mouth of Chukachida River, at 57°40′ N; 127°33′ W, at 5200 feet elevation, in tundra, on Jurassic volcanic rocks.
8. S.W. Mt. Will. Pass Lakes, ca 6 miles southwest of Mt. Will, at 57°29′ N; 128°53′ W, at 6500 feet elevation, in Alpine tundra on talus and outwash of Bowser Formation.
9. Griffith Creek. Head of Griffith Creek, on Bowser Formation, at 7000 feet elevation, at 57°28′ N; 128°28′ W. Alpine tundra.
10. Caribou Hide. At Caribou Hide, along the Stikine River at 57°27′ N; 127°34′ W, at 3700 feet elevation, in open woods, on river fill.
11. Tuaton Lake. West side of Tuaton Lake, at 57°17′ N; 128°06′ W, at 6000 feet elevation, in alpine tundra, on Bowser Formation.
12. Stalk Ridge. Northeast Stalk Ridge, at 57°09′ N; 127°37′ W, at 6000 feet elevation, on siliceous conglomerates, of Bowser Formation, in Alpine tundra.
13. Stalk Peak. Northwest spur of Stalk Peak, at 57°08′ N; 127°44′ W, at 6000 feet elevation, in alpine tundra, on barren shale slope of Bowser Formation.
14. Stalk Lakes. East shore at south end of the north-

ernmost lake of Stalk Lakes, at 57°07′ N; 127°36′ W, at 4500 feet elevation, in meadows, on alluvium.

15. N. Kitchener Lake. Ca 4 miles north of Kitchener Lake, at 57°07′ N; 127°32′ W, at 5000 feet elevation, in alpine tundra on alluvium.
16. Kitchener Crag. Rocky, bedrock ridge crest, immediately west of Kitchener Crag, southwest of Kitchener Lake, at 57°01′ N; 127°26′ W, at 6500 feet elevation, in alpine tundra on Bowser Formation.
17. Kitchener Lake. Along south shore of Kitchener Lake, at 57°11′ N; 126°57′ W, at 5000 feet elevation, in alpine tundra on Triassic marble.
19. N. tip Thutade Lake. Northwest shore, north tip of Thutade Lake, at 57°08′ N; 126°54′ W, at 3700 feet elevation, in Boreal Forest, on granite bedrock.
20. N.W. Tatlatui Lake. Ca 3 miles northwest of Tatlatui Lake, at 56°58′ N; 127°23′ W, at 6000 feet elevation, in alpine tundra on Bowser Formation.
21. Skeena River Valley, Tatlatui Range, ca 6 miles south and 60° west of Alma Peak, at 56°40′ N; 127°38′ W, on slope above Skeena River Valley, at 6200 feet elevation, ca 17 miles southwest of Thutade Lake, in Bowser beds or Takla Formation.
22. Head Thutade Creek. Tatlatui Range, in pass between head of Thutade Creek and unnamed tributary of Skeena River, ca 12 miles southwest of Thutade Lake, at 56°44′ N; 127°33′ W, at 5600 feet elevation, in a fell field, on Asitka slate.
23. Thutade Creek. Near head of Thutade Creek, ca 5 miles southwest of Thutade Lake, at 56°47′ N; 127°18′ W, at ca 3800 feet elevation, on stream gravels, in willow heathland.
24. Tatlatui Lake. Tatlatui Lake shore, at 56°54′ N; 127°24′ W, at 4080 feet elevation, in beach deposits and morainic gravels, in mixed woodland.
25. S.W. Thutade Lake. Steep, southeast-facing slope, ca 2 miles due west of the southwest corner of Thutade Lake, at 56°47′ N; 127°17′ W, at 4500 feet elevation, on middle Bowser Formation.
26. Thutade Lake camp. West shore of Thutade Lake,

Fig. 15. North to the boundary fault zone at the west edge of the Sustut Basin exposed in the ridge crest immediately north of Thutade Lake at 56°50′ N; 127°12′ W. Minor affect of differences in lithology of Sustut Formation and the Bowser group shows in nearly uniform plant patterns. The alternating light-banded beds on the left are overturned, and sheared middle beds of the Sustut Formation and the more massive, nearly horizontal beds exposed on the left are in the Jurassic Bowser Formation, here composed of mudstone and minor beds of conglomerate. Krummholz of *Abies lasiocarpa* and open-grass and sedge-covered slopes.

FIG. 16. Northeast spur of Niven Peak at 56°56′ N; 126°52′ W, as seen from the east. The three low sawtooth-shaped ridges along the spur near the center of the photograph are held up by fossiliferous limestone at the top of the Cache Creek sequence and are at an elevation of approximately 7000 feet, 2000 feet above the valley floor. The general level spur toward the left is held up by graywacke sandstone at the base of the Triassic Takla sequence. The ragged ledge-forming exposures in the center and right are on the upper part of the volcanic Asitka sequence near Locality 33. The steep, apparently barren, slopes in center background are clothed with grassy alpine tundra dominated by *Festuca altaica*.

near south end, in mixed lodgepole pine, white spruce, alpine fir woodland, at 56°48′ N; 127°12′ W, at 3625 feet elevation, on morainic gravels.

27. Thutade Mt. On mountain behind camp at Thutade Lake, at 56°49′ N; 127°11′ W, at 5000-6000 feet elevation, in alpine tundra and steep grassy slopes, on Bowser Formation.
28. South Pass Peak. Ca 1.5 miles northwest of South Pass Peak, ca 7 miles south-southwest of "Thutade Village," at 56°42′ N; 127°09′ W, at 4300 feet elevation, in open woods, on alluvium.
29. Coal beds. In saddle of mountains, ca 5 miles southeast of south end of Thutade Lake, at 56°45′ N; 127°05′ W, at ca 5000 feet elevation, in alpine tundra and barrens on Tertiary Sustut coal beds.
30. Mt. Jorgensen. On Mt. Jorgensen, ca 12 miles northeast of "Thutade Village," at 56°54′ N; 126° 56′ W, at 5200 feet elevation, in alpine tundra on Sustut Formation.
31. Firesteel River. Ca 7 miles east of Kitchener Lake, at 57°03′ N; 127°10′ W, 4000 feet elevation, in Boreal Forest on alluvium.
32. Niven Creek. Tributary of Niven Creek, ca 3 miles east-southeast of Dewar Peak, at 56°42′ N; 126°52′ W, at 4500 feet elevation, in open willow-meadow lands surrounded by white spruce woods, on alluvium.
33. W. and S.W. Dewar Peak. Ridge crests, west and southwest of Dewar Peak, at ca 56°42′ N; 126°50′ W, at ca 5500 feet elevation, in alpine tundra in Upper Takla Group volcanic rocks.
34. Dewar Peak vicinity. Alpine tundra, at 56°45′ N; 126°45′ W, at 6000-6500 feet elevation, on lavas of the Asitka Group.
35. Dewar Peak NNE. Ca 3 miles NNE Dewar Peak, at 6125 feet elevation on Tertiary Sustut Formation, at 56°46′ N; 126°45′ W. Alpine tundra and fell fields.
36. Thorne Lake. Marshy east shore of Thorne Lake, at 56°50′ N; 126°42′ W, at 3900 feet elevation. Marshy east shore, on alluvium.

37. Mt. Savage. Massif south of Moosevale Creek, ca 3 miles southeast of Dewar Peak, at 56°40′ N; 126°45′ W, at 6000 feet elevation, in krummholz and alpine tundra, on lavas of the Takla Group.
38. New Wellington. At New Wellington mining camp, in Moose Valley at the mouth of Moosevale Creek, at 56°44′ N; 126°37′ W, at ca 4000 feet elevation, in wet to dry meadow, stream bank, and open lodgepole pine woods on alluvium.
39. Rognaas Peak. Northeast spur of Rognaas Peak, at 57°09′ N; 127°04′ W, at 4700 feet elevation, in open woods, on cherty rubble at Triassic Takla Formation.
40. Trygve Lake. North shore west end, on glacial moraine, at 56°59′ N; 127°30′ W, at 4570 feet elevation. Heathland on Pleistocene glacial moraine.
41. Lawyer Pass. North side of hill, 4 miles east of Lawyer Pass, at 57°18′ N; 127°13′ W, at 6000 feet elevation, in deep soils over Jurassic Takla Group (?) volcanics, in alpine tundra.

ANNOTATED LIST OF SPECIES

The following list of species was collected in northern British Columbia during the summer of 1969. Two main collections are included; one by S. L. Welsh and J. K. Rigby taken during the first two weeks of June, and a second collected by J. K. Rigby and G. Cuddy throughout the growing season of 1969. In order to save space, the collection localities have been numbered and described separately from the list of species. The names of the collectors are abbreviated; with WR standing for Welsh and Rigby, and RC for Rigby and Cuddy.

Fig. 17. Northwest along the eastern base of the Niven Peak massif at 56°46′ N; 126°51′ W. Light colored tuffaceous and rhyolitic units are a distinctive feature in the central part of the photograph beyond the helicopter. Well-bedded rocks in the middle distance are on the southeast spur of Forrest Mountain to the northeast of Niven River. Peaks along the skyline are in the vicinity of Fredrickson Peak and other peaks to the northeast to Thutade Lake and are composed of Takla volcanics cut by Ominica intrusive granodiorite. Thorne Lake, Locality 36, occurs in the valley between the batholithic belt and Mount Forrest. Locality 38, at New Wellington, is in Moose Valley a short distance to the right of the photograph. Ridge crest dominated by *Potentilla hyparctica, Lupinus arcticus, Dryas integrifolia, Antennaria monocephala,* and *Selaginella sibirica.*

FIG. 18. Northwest toward the northeast spur of Niven Peak with Cache Creek rocks forming most of the central exposures and Asitka rocks forming the light colored to brilliantly colored rocks along the right part of the photograph at 56°47′ N; 126°50′ W. Collections from Locality 35, Dewar Peak north northeast, were collected from the saddle and cliff zone separating the light and dark-colored rocks at the right center skyline. Sparse alpine tundra dominated by crustose lichens in foreground, with krummholz and tundra covered slopes in center and on ridge in background.

Collection localities are numbered from northern portions of the region southward and are not in order as to date of collections.

In the checklist, the subdivisions are arranged in phylogenetic sequence, but families, genera, species, and infraspecific taxa are in alphabetical order. A summary of the number of taxa is presented at the end of the checklist (Fig. 33). All specimens are deposited in the herbarium of Brigham Young University (BRY). Identifications were based on works by Hulten (1968) and Welsh (1971).

LYCOPSIDA

Lycopodiaceae Clubmoss Family

Lycopodium alpinum L.

Locality #26, WR 8996, 7 June. Ground layer in woods, on glacial moraine.

Lycopodium annotinum L.

ssp. *annotinum*

Locality =26, WR 8992, 7 June. Ground layer in woods, on glacial moraine. This species sporulated during the second week of June and covered the surface of Thutade Lake with spores. Onshore breezes concentrated them along the beaches in windrows to half an inch deep.

Lycopodium complanatum L.

Locality #26, WR 8991, 8994, 7 June. Ground layer in woods, on glacial moraine.

Lycopodium selago L.

Locality #12, RC 139, 30 June; #25, WR 9041, 9 June, in alpine tundra, on Bowser and Sustut Formations.

Selaginellaceae Selaginella Family

Selaginella sibirica (Milde.) Heiron

Locality #24, WR 9037, 9 June. Ridge crest, on lavas, in alpine tundra. This is evidently the first report of *S. sibirica* for British Columbia.

SPHENOPSIDA

Equisetaceae Horsetail Family

Equisetum arvense L.

Locality #26, WR 9074, 14 June. In thicket along stream bank, on glacial moraine.

Equisetum variegatum Schleich.

Locality #23, WR 9091, 14 June. In moist site, on gravel bar.

PTEROPSIDA FILICINEAE

Polypodiaceae Fern Family

Cryptogramma crispa (L.) R. Br.

Locality #25, WR 9111, 14 June. Rock outcrop, on steep south-facing, grassy slope, on Bowser Formation.

Cystopteris fragilis (L.) Bernh.

Locality #25, WR 9098, 14 June. Rock outcrop, on steep south-facing, grassy slope, on Bowser Formation.

PTEROPSIDA GYMNOSPERMAE

Pinaceae Pine Family

Abies lasiocarpa (Hook.) Nutt.

Locality #26, WR 8981, 7 June. A dominant in the Boreal Forest, and the chief component of the well-developed krummholz of the region.

Juniperus communis L.

Locality #26, WR 8989, 7 June. Open woods, on morainic gravels.

Picea glauca (Moench) Voss

Locality #6, RC 262, 6 Aug.; 26, WR 8985, 7 June. A dominant species in the Boreal Forest.

Pinus contorta Dougl.

var. *latifolia* Engehn.

Locality #1, RC 275, 13 Aug.; #6, RC 263, 6 Aug.; #26, WR 8990, 7 June. A dominant species in the Boreal Forest.

PTEROPSIDA ANGIOSPERMAE
DICOTYLEDONEAE

Betulaceae Birch Family

Alnus crispa (Ait.) Pursh

var. *laciniata* Hultén

Locality #1, RC 269, 13 Aug. Streamsides.

Alnus incana (L.) Moench

ssp. *rugosa* (Dukoi) R. T. Clausen

var. *occidentalis* (Dipp.) C. L. Hitchc.

Locality #26, WR 8984, 7 June. Lake shores.

Betula glandulosa Michx.

var. *glandulosa*

Locality #1, RC 266, 13 Aug. 1969; Locality # 6, RC 264, 6 Aug. 1969; #26, WR 8983, 7 June. Boreal Forest, taiga, and heathlands.

Boraginaceae Borage Family

Hackelia jessicae (McGregor) Brand

Locality #25, WR 9116, 14 June; #26, RC 148, 4 July. A component of the steep meadows along snow slide tracks on south-facing slopes.

Mertensia paniculata (Ait.) D. Don

ssp. *paniculata*

Locality #3, RC 219, 27 July; # 5, RC 170, 22 July; #18, RC 129, 30 June; #26, WR 9062, 13 June; # 30, RC 11, 17 June; #26, RC 47, 19 June. Lake shores, woods, morainic gravels, meadows, heathlands, and alpine tundra.

Myosotis sylvatica Hoffm.

Locality #3, RC 209, 216b, 27 July; #7, RC 257, 5 Aug.; #8, RC 238, 240, 1 Aug.; #16, RC 23, 31, 19 June; #25, WR 9107, 14 June; #28, RC 2b, 16 June; #32, WR 9050, 10 June. Alpine tundra, meadows, and talus.

Campanulaceae Bellflower Family

Campanula lasiocarpa Cham.

Locality #3, RC 217, 27 July; #7, RC 249, 5 Aug.; #12, RC 137b, 30 June; #13, RC 100, 27 June; #34, RC 80a, 25 June. Fell fields, alpine tundra, and talus slopes, on micaceous schists, siliceous conglomerate, and lavas.

Caprifoliaceae Honeysuckle Family

Linnaea borealis L.

var. *longiflora* Torr.

Locality #5, RC 171, 22 July; #6, 193, 26 July. Woods and thickets, on glacial moraine.

Lonicera involucrata (Richards.) Banks

Locality #26, WR 9083, 14 June; do RC 71, 92, 25 June; do RC 158, 11 July. Lake shores and woods, on glacial moraine. These collections represent a range extension northward in British Columbia.

Viburnum edule (Michx.) Raf.

Locality #25, WR 9092, 14 June; #26, WR 9084, 14 June; do RC 88, 25 June. Lake shores, woods, and slopes, on glacial moraine and Bowser Formation.

Caryophyllaceae Pink Family

Arenaria rubella (Wahl.) Smith

Locality #2, RC 235, 28 July (glabrous phase); #27, RC 123, 29 June. Alpine tundra, on weathered serpentine intrusive.

Arenaria sajanensis Willd.

Locality #29, WR 9134, 15 June. Noted only on Tertiary Sustut coal beds.

Cerastium arvense L.

Locality #2, RC 228, 28 July; #25, WR 9123a, 14 June. Alpine tundra and meadows, on weathered serpentine-intrusive and on Bowser Formation.

Cerastium beeringianum Cham. & Schlecht.

Locality #18, RC 128a, 30 June; #36, RC 48d, 19 June. Alpine tundra and alluvium along

FIG. 19. A continuation toward the left of Figure 20 and shows mainly Jurassic volcanic rocks. Locality 9, Griffith Creek, is in the general vicinity at approximately 7000 feet elevation. Krummholz, alpine tundra, talus slopes, and barrens.

lakes and streams, on Triassic (?) marble and alluvium.

Silene acaulis L.

var. *exscapa* (All.) DC.

Locality #32, WR 9052, 10 June; #34, WR 8978, 7 June; do WR 9031, 8 June. Alpine tundra and fell fields, on alluvium and lavas.

Stellaria longipes Goldie

var. *altocaulis* (Hultén) C. L. Hitchc.

Locality #16, RC 21a, 28a, 19 June; #36, RC 48c, 19 June. Alpine tundra, on Bowser Formation and alluvium.

var. *longipes*

Locality #10, RC 124a, 29 June. River gravels.

Fig. 20. Northwest across the headwaters of Griffith Creek in the east central part of the Spatsizi Quadrangle from 59°29′ N; 128°25′ W. Ragged exposures along the skyline are in the Jurassic Eaglenest volcanic rocks. The smooth saddle and relatively rounded rocks toward the right are folded Sustut rocks. A well-exposed major fault here separates the Jurassic and Tertiary formations along the west side of the Sustut Basin. Krummholz and alpine tundra on solifluction slopes and talus.

FIG. 21. Lehi F. Hintze in argillaceous exposure in the upper part of the Bowser Formation at approximately 57°20′ N; 28°33′ W, on ridges west of Buckinghorse Creek, which is in the background. Grassy slope dominated by *Festuca altaica*, with *Potentilla diversifolia* in the foreground.

Chenopodiaceae Goosefoot Family

Chenopodium capitatum (L.) Asch.

Locality #4, RC 187, 22 July. Glacial moraine, in open woods.

Compositae Composite Family

Achillea millefolium L.

ssp. *borealis* (Bong.) Breitung

Locality #6, RC 200, 26 July; #7, RC 251c, 5 Aug. Moraines, river gravels, and volcanic rocks in tundra and woods.

ssp. *lanulosa* (Nutt.) Piper

Locality #5, RC 168a, 22 July; #27, RC 119, 29 June; #36, RC 50, 19 June. Moraines, river gravels, and Bowser Formation in mountain slopes.

Agoseris aurantiaca (Hook.) Greene

Locality #3, RC 222, 27 July; #6, RC 194,

Fig. 22. West across the western edge of the Spatsizi Plateau from 57°42′ N; 128°43′ W, across Coldfish Lake Valley into the Eaglenest Range during one of the first major snowstorms in early August. The snow line is at about the timberline and snow blankets the upper-elevation tundra surfaces developed on volcanic rocks in the background and on flat-lying siliceous sedimentary rocks in the foreground. Alpine tundra.

26 July; #26, RC 152, 11 July. Ridge tops and mountain slopes, in micaceous schists and moraines, in alpine tundra and woods.

Antennaria alpina (L.) Gaertn.

var. *stolonifera* (Porsild) Welsh

Locality #22, WR 9133a, 15 June; #36, RC 55a, 19 June. Alpine tundra, heath, and woods, on slate and alluvium.

Antennaria monocephala DC.

Locality #20, RC 20, 18 June; #21, WR 9089, 14 June; #29, WR 9133, 15 June; #34, WR 9038, 9 June; #37, WR 9009, 8 June. Alpine tundra and heathlands, on Bowser Formation, Tertiary Sustut coal beds and lavas.

Antennaria neglecta Greene

Locality #26, RC 89, 25 June. Open woods on glacial moraine.

Antennaria rosea Greene

Locality #25, WR 9112a, 15 June. Open woods and meadows, on alluvium.

Arnica cordifolia Hook.

Locality #25, WR 9110, 14 June; #26, 87, 25 June. Open woods, on alluvium and glacial moraine.

Arnica latifolia Bong.

Locality #3, RC 215, 27 July; #7, RC 254, 5 Aug.; #26, WR 9076, 14 June; do RC 36, 19 June; do RC 95, 25 June; do RC 165, 11 July; #39, RC 135, 30 June. Alpine tundra, meadows, and open woods, on micaceous schist, glacial moraine, and cherty rubble.

Artemisia campestris (L.) DC.

ssp. *borealis* (Pallas) H. & C.

var. *borealis*

Locality #5, RC 180, 22 July. Glacial moraine, in woods.

Artemisia nowegica Fries

var. *saxatilis* (Besser) Jeps.

Locality #3, RC 223, 27 July; #7, RC 258a, 5 Aug.; #21, WR 909, 14 June; #26, WR 9078, 14 June; #29, WR 9132a, 15 June. Open woods, alpine tundra, and fell field, on micaceous schists, coal beds, and glacial moraine.

Erigeron humilis Grah.

Locality #8, RC 239a, 1 Aug.; #17, RC 21, 19 June; #27, RC 121, 29 June; #29, WR 9128,

FIG. 23. Lehi F. Hintze photographing Monkshood and sedge along the north flank of the northwest spur of Mt. Will, near Locality 8, on siliceous Jurassic volcanic rocks of the Eaglenest volcanic sequence at approximately 57°32′ N; 128°47′ W, and at an elevation of 6000 feet. Alpine tundra, with *Hierochloe alpina, Aconitum delphinifolium*, and *Carex*.

15 June; #36, RC 48b, 19 June. Alpine tundra and talus slopes, on Bowser Formation, and alluvium.

Erigeron lonchophyllus Hook.

Locality #4, RC 189b, 22 July. Glacial moraine, in woods.

Erigeron peregrinus (Pursh) Greene ssp. *callianthemus* (Greene) Cronq.

Locality #3, RC 212, 27 July; #7, RC 247, 5 Aug.; #25, WR 9101, 14 June; #26, RC 74, 74a, 93, 25 June. Open woods, meadows, and alpine tundra, on micaceous schist.

Hieracium gracile Hook.

Locality #3, RC 220b, 27 July. Alpine tundra, on micaceous schist.

Petasites frigidus L.

var. *frigidus*

Locality #14, RC 60, 25 June; #22, WR 9056, 12 June; #27, RC 144b, 30 June. Alpine tundra, fell fields, and meadows, on alluvium and Bowser Formation.

var. *palmatus* (Ait.) Cronq.

Locality #38, WR 9025, 8 June. Wet meadow, along stream.

Senecio lugens Richards.

Locality #17, RC 97, 27 June; #18, RC 130, 30 June. Alpine tundra and woods, on Triassic (?) marble and alluvium.

Senecio triangularis Hook.

Locality #3, RC 210, 225, 27 July; #7, RC 258, 5 Aug.; #25, WR 9122, 14 June; #26, RC 166, 11 July. Meadows, open woods, and alpine tundra, on micaceous schist, Bowser Formation, and morainic gravels.

Solidago multiradiata Ait.

Locality #5, RC 169a, 22 July; #6, RC 201,

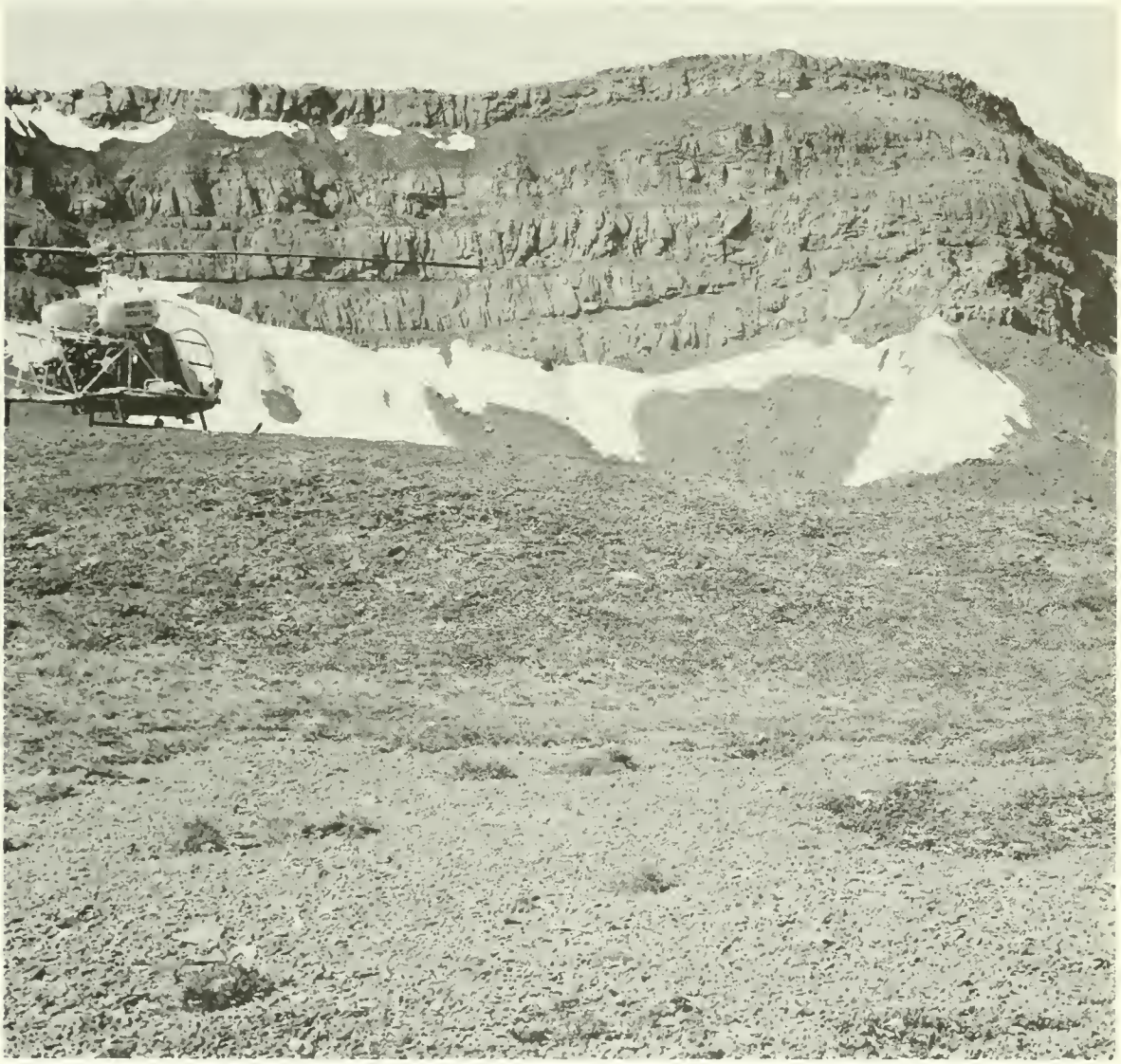


Fig. 24. View westward toward a conglomerate and coal-bearing sequence in the lower part of the Bowser Group on the northeast side of Stalk Ridge. Conglomerate and sandstone form the prominent ledges with coal and carbonaceous shale forming the distinctive slope zone. Plants in the foreground are growing on siliceous pebbly conglomerate and are typical of alpine tundra along ridge crests. The foreground is at an elevation of 6500 feet and at 57°09′ N; 127°35′ W, a short distance south of collecting locality 12. Plants from Locality 12 were collected on the same beds of sandstone and conglomerate shown above the talus.

FIG. 25. Horizontally bedded Sustut rocks on the northwestern part of the Mount Jorgensen massif at the northwest end of Tabletop Mountain at 56°57′ N; 127°09′ W, at 6500 feet in the Spatsizi Plateau. Peaks along the skyline in the distance are part of the folded Bowser sequence west of the Sustut Basin. The alternating terraces are produced by interbedded resistant conglomerate and sandstone. Easily eroded shales form vegetated stripped surfaces on top of the sandstone ledges. Alpine tundra heathlands and limited krummholz vegetation.

201a, 26 July; #7, RC 253, 5 Aug. Open woods, heathlands, and alpine tundra, on moraine and volcanic rocks.

Taraxacum ceratophorum (Ledeb.) DC.

Locality #8, RC 239, 1 Aug.; #13, RC 99b, 27 June; #36, RC 50a, 19 June. Talus slopes and ridges, in woods, meadows, and alpine tundra, on Bowser Formation and alluvium.

Taraxacum eriophorum Rydb.

Locality #17, RC 22, 19 June; #20, RC 19b, 18 June. Alpine tundra, fell fields, and open woods, on alluvium, and Bowser Formation.

Cornaceae Dogwood Family

Cornus canadensis L.

Locality #26, WR 9075, 14 June; do RC 9, 17 June. Woods, on morainic gravels.

Crassulaceae Stonecrop Family

Sedum lanceolatum Torr.

Locality #6, RC 191, 26 July; #30, RC 14, 17 June. Glacial moraine in open woods, and alpine tundra on Sustut Formation.

Cruciferae Mustard Family

Arabis divaricarpa A. Nels.

Locality #4, RC 186, 26 July. Glacial moraine in open woods.

Arabis drummondii Gray

Locality #19, RC 114, 28 June. On granite bedrock, in open woods.

Arabis glabra (L.) Bernh.

Locality #25, WR 9103, 14 June; #26, RC 37d, 19 June; #28, RC 4, 16 June. Alluvium and morainic gravels in open woods and meadows.

Arabis lemmonii Wats.

Locality #33, WR 9050a, 10 June. Alpine tundra, on volcanic rocks.

Arabis lyrata L.

Locality #8, RC 237b, 1 Aug.; #14, RC 56, 25 June; #28, RC 3, 16 June; #29, WR 9142a, 15 June. Open woods, heathlands, and alpine tundra, on alluvium, talus, and coal beds.

Barbarea orthoceras Ledeb.

Locality #20, RC 37f, 19 June; do, RC 79, 25 June. Morainic gravels in open woods.

Cardamine pratensis L.

Locality #14, RC 60b, 25 June. Alluvium, in meadows.

Draba aurea Vahl

Locality #5, RC 178, 22 July; #6, RC 197, 26 July; #40, RC 101, 28 June. Glacial moraines, in open woods and heathlands.

Draba borealis DC.

var. *maxima* (Hultén) Welsh

Locality #7, RC 251, 5 Aug.; #25, WR 9112b, 14 June; #27, RC 144, 30 June. Meadows, open woods, and alpine tundra; on volcanic rocks, Bowser Formation, and alluvium.

Draba incerta Payson

Locality #13, RC 100b, 27 June; #16, RC 28b, 19 June; #27, RC 144a, 30 June; #29, WR 9130, 15 June; #34, WR 9036, 9 June. Alpine tundra and fell fields, on Bowser Formation, coal beds, and volcanic rocks.

Draba nivalis Payson

var. *elongata* Wats.

Fig. 26. West from the northeast spur of Sustut Peak at 56°35′ N; 120°36′ W, across the Sustut River Valley at 3500 feet to the southwest spur of Savage Peak which rises to over 7000 feet. Lower dark green agglomerate of the Takla Group forms the prominent high serrated peaks in the right center and right of the photograph. The upper part of the Takla group forms the somewhat rounded cliffs along the skyline to the left. Prominent steep valleys are carved in softer more distinctly bedded tuffaceous and graywacke sandstone beds interbedded with the agglomerate. *Dryas integrifolia* and crustose lichen fell field in the foreground.

FIG. 27. Collection locality 2, shown by the arrow, is at an asbestos prospect near Letain Lake, the prominent lake in the left intermediate distance. Country rocks here are metamorphosed argillite, argillaceous quartzite, and volcanic rocks which have been intruded by serpentine peridotite. Serpentine peridotite forms the light-colored exposures in the background along the ridge crest immediately beyond the collecting locality. Low-rank mica schist forms the low rounded hills in part of the area. The Locality 2 collecting site is at 58°20′ N; 128°45′ W, at approximately 5400 feet in elevation. Alpine tundra, heathlands, krummholz and meadows.

Locality #37, WR 9009a, 8 June. Alpine tundra, on lavas.

Draba stenoloba Trautv.

Locality #28, RC 3a, 16 June. Alluvium, in heathlands.

Thlaspi arvense L.

Locality #4, RC 185, 22 July. Glacial moraine, in open woods.

Elaeagnaceae Oleaster Family

Shepherdia canadensis (L.) Nutt.

Locality #1, RC 270, 13 Aug.; #26, WR 9065, 13 June. Lake shores and stream banks, on glacial moraine and stream terrace gravels, in woods.

Empetraceae Crowberry Family

Empetrum nigrum L.

Locality #1, RC 278, 13 Aug.; #26, WR 8982, 7 June. Open woods and heathlands, on alluvium and moraines.

Ericaceae Heath Family

Arctostaphylos uva-ursi (L.) Spreng.

Locality #1, RC 279, 13 Aug.; #26, WR 8997, 7 June; do RC 37, 19 June; do RC 72, 25 June; #30, RC 7, 17 June. Alluvium glacial

Fig. 28. View looking northwest from Triangulation Station 6539 about four miles east of the junction of the right and left forks of Kehlechoa River at 59°09′ N; 128°37′ W. Rocks in the foreground are metamorphosed phyllite and slate Unit 14 on the Cry Lake quadrangle geologic map of Geologic Survey of Canada. Rocks of Unit 11-B and 12 of the Cry Lake quadrangle can be seen across Kehlechoa River in the background, on the right of the photograph along the crest of the ridge in the middle distance between the two forks of Kehlechoa River. Alpine tundra dominated by species of *Carex*, *Dryas*, and *Lichen*.

FIG. 29. View towards the northwest along the northeast face of Stalk Ridge. The Stalk Ridge collection at Locality 12, 57°09′ N; 127°37′ W, at approximately 6000 feet, was made in the ledges at the extreme right margin of the photograph. All the rocks seen here are in the Bowser formation. Plants from Locality 12 were collected principally off the siliceous conglomerate and sandstone beds which form the prominent ledges in the intermediate distance. Alpine tundra and fell fields.

moraine and Sustut Formation in open woods and alpine tundra.

Arctostaphylos alpina (L.) Spreng.
var. *alpina*
Locality #37, WR 9011, 8 June 1969. Alpine tundra, on lavas.

Cassiope mertensiana (Bong.) D. Don
Locality #3, RC 215b, 27 July; #15, RC 18, 18 June; #18, RC 134, 30 June. Alpine tundra and heathlands, on micaceous schist, alluvium, and marble.

Cassiope tetragona (L.) D. Don
var. *saximontana* (Small) C. L. Hitchc.
Locality #29, WR 9141, 15 June; #34, RC 80, 25 June; #35, WR 9042, 9 June. Alpine tundra and heathlands, on coal beds and lavas.

Ledum groenlandicum Oeder
Locality #1, RC 277, 13 Aug.; #5, RC 177, 22 July. Glacial moraine and river terrace gravels, in woods.

Phyllodoce empetriformis (Sm.) D. Don
Locality #18, RC 133, 30 June; #29 WR 9138, 15 June; #30, RC 10, 17 June. Alpine tundra and heathlands, on marble, coal beds, and sandstone.

Phyllodoce glanduliflora (Hook.) Coville
Locality #2, RC 231d, 28 July; #18, RC

132, 30 June; #26, RC 91, 25 June; #29, WR 9139, 15 June; #37, WR 9010, 8 June. Alpine tundra, heathlands, and open woods, on weathered serpentine intrusive, marble, glacial moraines, coal beds, and lava.

Vaccinium caespitosum Michx.

Locality #25, WR 9099, 14 June; #26, WR 9079, 14 June; do RC 72b, 25 June. Open woods and meadows on morainic gravels and alluvium.

Vaccinium membranaceum Dougl.

Locality #26, WR 9063, 13 June. Open woods on morainic gravels.

Vaccinium vitis-idaea L.

Locality #1, RC 276, 13 Aug.; #12, RC 141, 30 June. Open woods and heathlands, on alluvium and siliceous conglomerate.

Fumariaceae Fumitory Family

Corydalis sempervirens (L.) Pers.

Locality #1, RC 280, 13 Aug. River terrace gravels, in open woods.

Fig. 30. Southeast toward the southwest Mt. Will glacier from 57°32′ N; 128°50′ W. Rocks along the skyline toward the left on the south spur of Mt. Will are held up by Eaglenest volcanics which are here essentially flat lying. Rocks in the center and the center right which form the high ledges are the topmost beds of the Eaglenest volcanic sequence and are overlain by shaly exposures of the Bowser beds at the upper right. Mt. Will rises to approximately 8000 feet above valleys at 5000 to 6000 feet. Alpine barrens and fell fields.

FIG. 31. Omineca and Sustut highlands looking southeast from Sustut Peak towards Sustut Lake from 56°36′ N; 126°32′ W. Outcrops immediately beyond the helicopter are of the Asitka and Cache Creek Groups and are dipping steeply toward the southwest. Asitka Peak, elevation 7055 feet, is the isolated mountain beyond Sustut Lake, elevation 4250 feet, and is composed in large part of southwest dipping Takla volcanics. High peaks along the skyline in the distance are in the Ingenika and Osilinka ranges and are composed in large part of Takla volcanics intruded by Omineca granodiorite and quartz diorite. Sparse alpine tundra, with *Lycopodium selago, Cassiope tetragona, Dryas integrifolia* and *Salix reticulata.*

Gentianaceae Gentian Family

Gentiana glauca Pallas

Locality #3, RC 215a, 27 July; #7, RC 252b, 5 Aug.; #12, RC 136, 30 June; #18, RC 128, 30 June; #27, RC 121a, 29 June. Alpine tundra and heathlands, on micaceous schist, volcanic rocks, siliceous conglomerate, and Bowser Formation.

Gentianella amarella (L.) Borner

Locality #5, RC 173, 27 July; #6, RC 196, 205, 26 July; do, RC 244, 3 Aug. Glacial moraine, in open woods.

Gentianella propinqua (Richards.) Gillette

Locality #2, RC 232, 28 July; #4, RC 189a, 22 July; #5, RC 172a, 22 July. Open woods, meadows, and alpine tundra, on weathered serpentine intrusive and glacial moraine.

Geraniaceae Geranium Family

Geranium crianthum DC.

Locality #14, RC 57, 26 June; #25, WR 9119, 14 June; #27, RC 122, 29 June. Open woods and meadows, on alluvium, glacial moraine, and Bowser Formation.

Leguminosae Legume Family

Astragalus alpinus L.

Locality #26, RC 37c, 19 June; #28, RC 28, 19 June; ;28, RC 1, 16 June; #36, RC 65, 19 June. Open woods, lake shores, and stream gravels.

Hedysarum alpinum L.

Locality #5, RC 175, 22 July; #6, RC 192, 26 July. Open woods, on glacial moraine.

Lupinus arcticus Wats.

Locality #5, RC 168, 22 July; #6, RC 204, 26 July; #33, WR 9048, 10 June; #34, WR 8980, 7 June; do WR 9001, 9092, 8 June; do WR 9033, 9 June; #36, RC 45, 19 June; #37, WR 9068, 13 June. Open woods, heathlands, and alpine tundra on moraine and lavas. All specimens collected in alpine sites are considerably

Fig. 32. Mr. Graham Cuddy, who assisted with some of the plant collection, on barren exposures of siltstone and coal in the upper part of the Sustut Formation at the south end of the Sustut Basin and the Spatsizi Plateau at Locality 29, at approximately 56°45′ N; 127°05′ W, at approximately 6500 feet in elevation. Semibarren alpine tundra, dominated by *Draba incerta* and *Carex podocarpa*.

more silky villous than those from woodland sites at lower elevations.

Lupinus nootkatensis Donn

var. *nootkatensis*

Locality #25, WR 9120, 14 June; #26, WR 8993, 7 June; do 9061, 13 June. Grassy slopes and open woods on glacial moraine. *L. nootkatensis* is common in the Pacific drainages, but has seldom been reported in the Mackenzie drainage. Thus, the report of this entity for the Thutade Lake vicinity is unique.

Oxytropis campestris (L.) DC.

var. *varians* (Rydb.) Barn.

Locality ±6, RC 204b, 26 July; #16, RC 25, 43, 19 June; ±29, WR 9131, 15 June; #34, RC 81, 25 June; ±37, WR 9004, 8 June. Alpine tundra and heathlands on Bowser Formation, coal beds, and lavas, and on glacial moraines and river gravels in open woods. The low elevation phases are similar to specimens from throughout Alaska and Yukon, but the alpine phases resemble var. *jordalii* (Porsild) Welsh in leaflet size and number. The flower size is within the range of variation of var. *varians* and apparenty the specimens are merely alpine dwarfs of var. *varians*.

Onagraceae Evening-Primrose Family

Epilobium alpinum L.

var. *alpinum*

Locality #7, RC 248a, 5 Aug.; #9, RC 237, 1 Aug.; #26, RC 34, 19 June. Alpine tundra and heathlands and open woods, on volcanic rocks, Bowser Formation, and lavas.

Epilobium angustifolium L.

Locality #5, RC 182, 22 July; #6, RC 202, 26 July; #7, RC 255, 5 Aug.; #19, RC 112, 28 June. Open woods, heathlands and tundra, on gravels, moraines, talus, and granite bedrock.

Epilobium latifolium L.

Locality #7, RC 246, 5 Aug.; #8, RC 236, 1 Aug.; #16, RC 96, 27 June. Alpine tundra stream gravels, and talus, on volcanic rocks and Bowser Formation.

Papaveraceae Poppy Family

Papaver alboroseum Hultén

Locality #16, RC 44, 19 June; do RC 98, 27 June. Alpine tundra on Bowser Formation. This is apparently the first report of *P. alboroseum* for British Columbia.

Papaver radicatum Rottb.

Locality #16, RC 30, 19 June; do RC 116, 28 June. Alpine tundra, on Bowser Formation.

Polemoniaceae Phlox Family

Polemonium caeruleum L.

ssp. *villosum* (Rud.) Brand

Locality ±2, RC 231a, 28 July; #3, RC 213 (white flowers), 214, 27 July; #5, RC 184, 22 July; #6, RC 207, 26 July; #7, RC 257, 5 Aug.; #14, RC 58, 25 June; #19, RC 111, 28 June; #31, RC 110, 28 June; ±36, RC 49b, 19 June. Alluvium and moraines along streams and lake shores in open woods, and in heathlands and tundra on weathered serpentine intrusive, micaceous schist, and granite.

Polemonium pulcherrimum Hook.

Locality #16, RC 27, 42, 19 June; ± 25, WR 9097, 14 June; #28 RC 2a, 16 June; #31, RC 108, 28 June; #33, WR 9049, 10 June. Alpine tundra, heathlands, meadows, and open

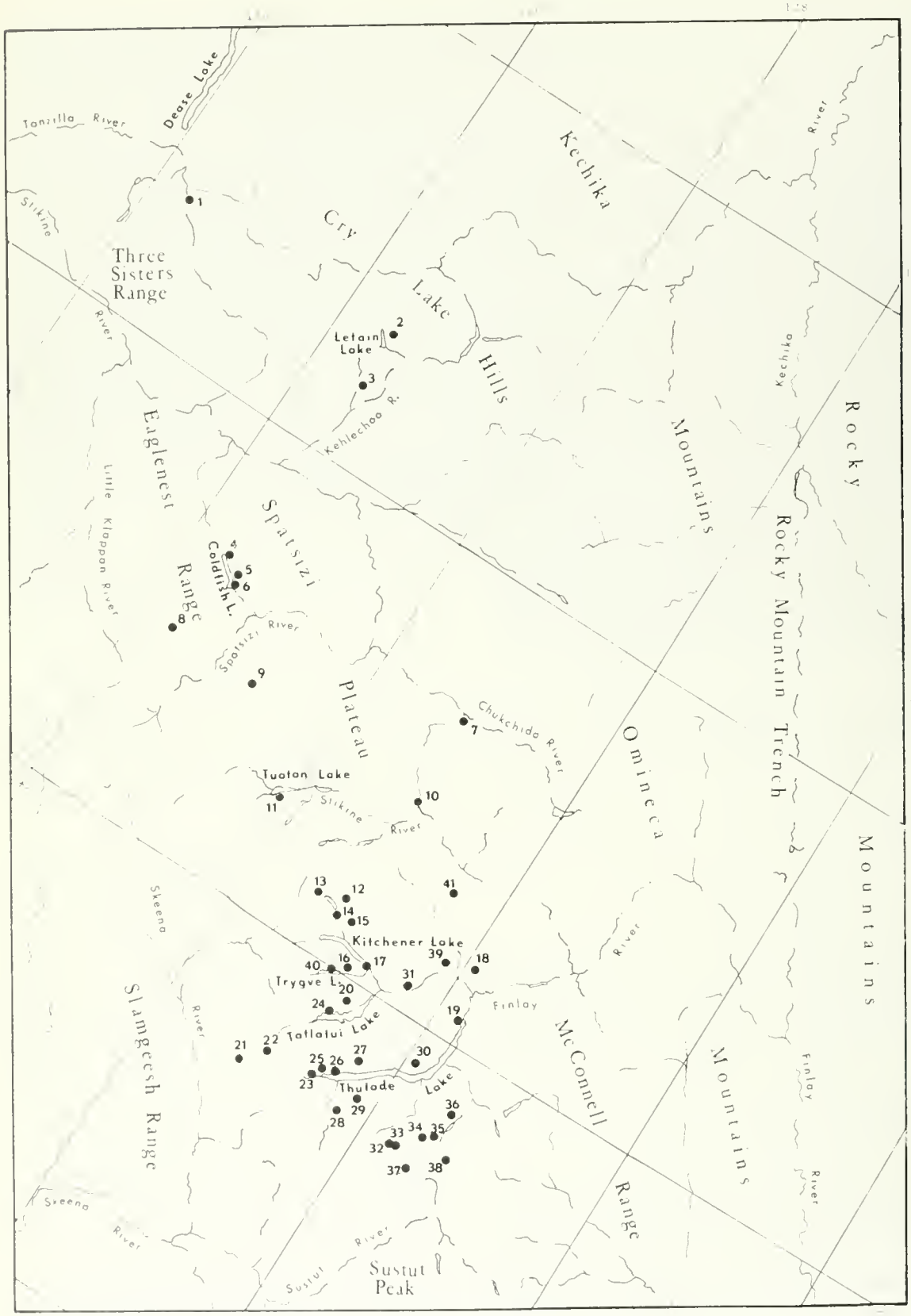


FIG. 33. Map of collecting localities in northern British Columbia.

woods on glacial moraine, talus, alluvium, Bowser Formation, and lavas.

Polygonaceae Buckwheat Family

Oxyria digynia (L.) Hill

Locality =7, RC 259, 5 Aug.; #22, 9055, 12 June. Alpine tundra, on volcanic rocks and slate.

Polygonum viviparum L.

Locality #2, RC 227, 28 July; #3, RC 216a, 27 July; #5, RC 177a, 22 July; #7, RC 248, 5 Aug.; #36, RC 48, 19 June. Open woods, heathland, and alpine tundra, on alluvium, glacial moraine, weathered serpentine intrusive, and micaceous schist.

Rumex acetosa L.

Locality #3, RC 224, 27 July; #25, WR 9102, 14 June; #28, RC 5, 16 June; #38, WR 9016, 8 June. Open woods and meadows, on alluvium and micaceous schist.

Fig. 34. Sustut Peak, the sharp glaciated horn near the upper center of the photograph, is one of the striking topographic features of the Sustut region near the southern border of the area investigated. It is held up by massive volcanic rocks of Triassic age and is flanked by lower Triassic rocks and Paleozoic rocks in the long ridges at the northeastern base of the range and by Jurassic volcanic rocks at the southwestern base. The valleys are clothed by Boreal Forest which is continuous with krummholz upwards.

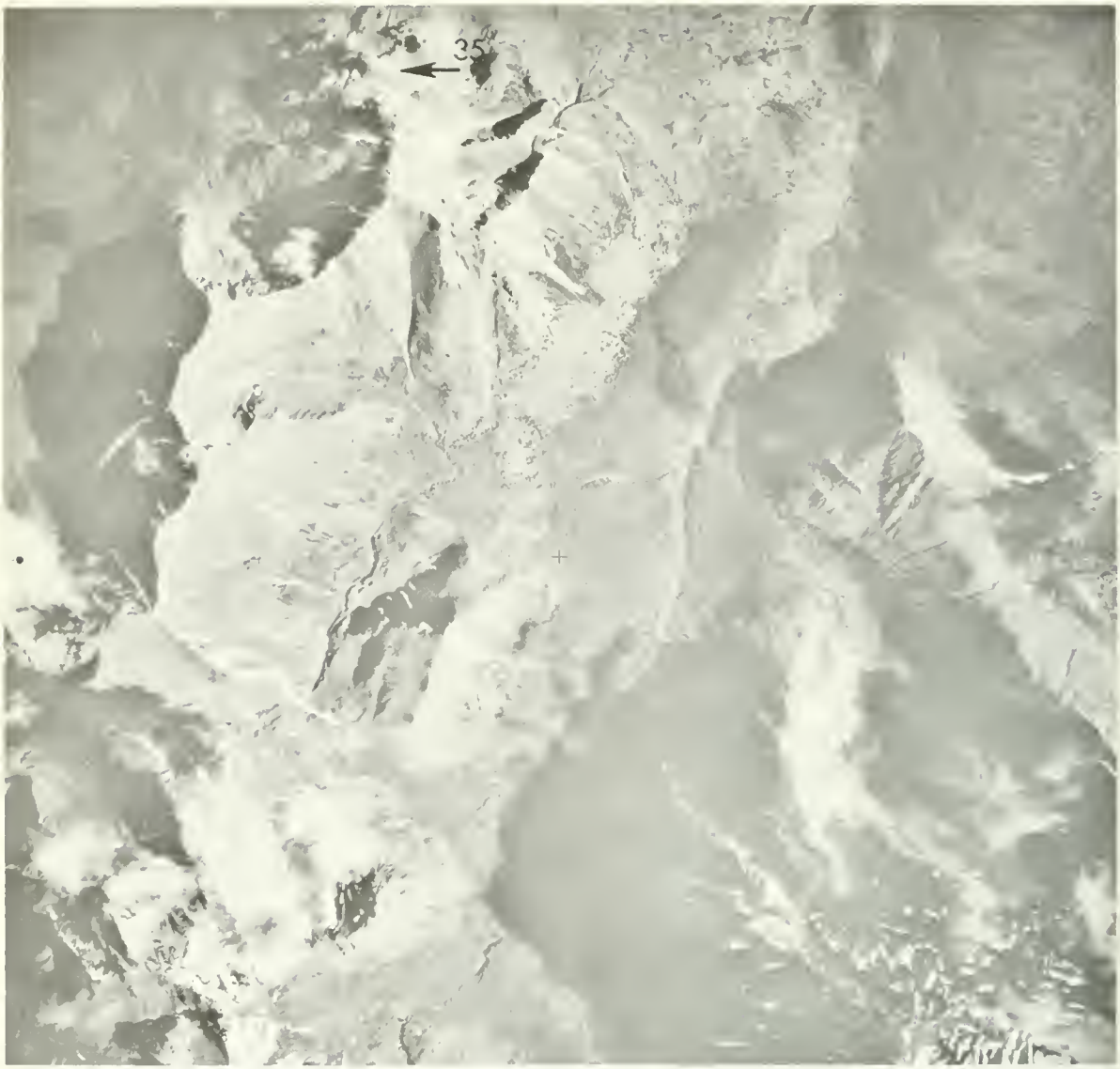


FIG. 35. Niven Peak, the sharply outlined peak along the ridge in the left center of the photograph, is typical of the topographic expression of Triassic and Upper Paleozoic rocks of the Sustut Peak region. Locality 35, near the upper margin, is on siliceous volcanic rocks of the Asitka Group.

Portulacaceae Purslane Family

Montia sarmentosa (C. A. Mey.) Robins.

Locality #2, RC 231e, 28 July; #3, RC 216, 27 July; #8, RC 237a, 1 Aug.; #11, RC 150, 8 July; #41, RC 103, 28 June. Alpine tundra, on weathered serpentine intrusive, micaceous schist, Bowser Formation, and on lavas.

Primulaceae Primrose Family

Trientalis europaea L.

Locality #26, WR 9073, 14 June; do RC 37b, 19 June; do RC 82, 25 June; #28, RC 8, 17 June. Glacial moraine and alluvium, in open woods.

Pyrolaceae Wintergreen Family

Pyrola asarifolia Michx.

Locality #5, RC 172, 22 July; #6, RC 203, 26 July; #26, RC 154, 11 July; do RC 84, 25 June. Open woods and meadows, on alluvium and glacial moraine.

Ranunculaceae Buttercup Family

Aconitum delphinifolium DC.

var. *delphinifolium*

Locality #3, RC 221, 27 July; #5, RC 179, 22 July; #6, RC 208, 26 July; #7, RC 256, 5 Aug.; RC 127, 30 June; #26, 159, 11 July; #27, RC 118, 29 June. Meadows, open woods, lake

shores, river banks, and alpine tundra, on alluvium, glacial moraines, talus slopes, micaceous schist, volcanic rocks, and Bowser Formation.

Anemone multifida Poir.

Locality #5, RC 195, 26 July; #15, RC 18a, 18 June; #33, WR 9051a, 10 June. Alpine tundra, heathlands, and open woods, on volcanic rocks, alluvium, talus, and glacial moraine.

Anemone narcissiflora L.

var. *monantha* Schlecht.

Locality #2, RC 233, 28 July; #3, RC 220a, 27 July; #41, RC 104, 28 June. Alpine tundra, on serpentine intrusives, micaceous schist, and volcanic rocks.

Anemone parviflora Michx.

Locality #5, RC 181, 22 July; #16, RC 31a, 19 June; #34, WR 9003, 9032, 8 June; #37, WR 9005, 8 June. Alpine tundra and open woods, on glacial moraine, Bowser Formation, and lavas.

Anemone richardsonii Hook.

Locality #26, WR 9071, 14 June; #28, RC 1a, 16 June. Dense woods, on alluvium.

Fig. 36. Collecting Locality 25 is on the southern flank of a high ridge of Bowser mudstone and sandstone on the north side of Thutade Creek, west of Thutade Lake. It is one of the most prolific localities collected during the summer.

FIG. 37. West end of Thutade Lake is bordered by mountains carved in mudstone and conglomerate of the Bowser Group. Locality 26 is at the campsite, on the lakeshore, and Locality 27 is on the high ridge behind camp to the north.

Aquilegia formosa Fisch. ex DC.

Locality #25, WR 9104, 14 June; #26, 146, 4 July. Grassy slopes, on talus.

Caltha leptosepala DC.

Locality #10, RC 124, 29 June; #19, RC 115, 28 June; #26, RC 147, 4 July; #26, RC 95a, 25 June; #38, WR 9020, 8 June. Stream banks and wet meadows, on alluvium and granite.

Delphinium glaucum Wats.

Locality #5, RC 183, 22 July; #6, RC 199, 26 July; #26, RC 160, 11 July. Open woods and meadows, on glacial moraine and alluvium.

Ranunculus eschscholtzii Schlecht.

Locality #8, RC 241, 1 Aug.; #10, RC 125a, 29 June; #16, RC 44b, 19 June; #25, WR 9123, 14 June; #26, WR 9000, 7 June; RC 6, 16 June; #29, WR 9126, 15 June; #33, WR 9047, 10 June. Open woods, meadows, alpine tundra, and heathlands, on talus, alluvium, Bowser Formation, coal beds, and volcanic rocks.

Ranunculus nivalis L.

Locality #12, RC 138, 30 June. Alpine tundra, on siliceous conglomerate.

Ranunculus occidentalis Nutt.

var. *brevistylus* Greene

Locality #8, RC 241a, 1 Aug.; #14, RC 61, 25 June. Open woods, meadows, and alpine tundra, on Bowser Formation, and alluvium.

Ranunculus pygmaeus Wahl.

Locality #12, RC 137, 30 June. Alpine tundra, on siliceous conglomerate.

Ranunculus unicinatus D. Don

Locality #26, RC 163, 11 July. Open woods, on glacial moraine.

Thalictrum alpinum L.

Locality #36, RC 51, 19 June. Marshy lake shore, in woodland.

Thalictrum occidentale Gray

Locality #25, WR 9121, 14 June; #26, WR 9067, 13 June; do RC 39, 19 June; do RC 78, 25 June; #36, RC 49, 19 June. Open woods, grassy slopes, meadows, and lake shores, on glacial moraine and alluvium.

Fig. 38. Mt. Jorgensen is held up by nearly horizontal alternating beds of conglomeratic sandstone and argillaceous mudstone. Sandstone beds form ledges and mudstone form slopes in the step-like erosional pattern well expressed in cirque floors. Locality 30 is on Mt. Jorgensen.

FIG. 39 Kitchener Lake is in the region between the folded mountains to the west and the Spatsizi Plateau to the east. Locality 17 is at the eastern end of the lake near its outlet. Locality 16 near Kitchener Crag is just off the photograph along the sharp ridge at the lower left, and is in Bowser shale and sandstone.

Rosaceae Rose Family

Dryas integrifolia Vahl

var. *integrifolia*

Locality #16, RC 41, 19 June; #35, WR 9039, 9 June; #37, WR 9070, 13 June. Alpine tundra, on Bowser Formation, Sustut, a dominant species.

Dryas octopetala L.

var. *kamtschatica* (Juz.) Hultén

Locality #2, RC 231c, 28 July; #13, RC 99, 27 June. Alpine tundra, on serpentine intrusive and Bowser Formation. These specimens approach *D. integrifolia* but possess glands similar to *D. octopetala*.

Fragaria virginiana Duchesne

var. *glauca* Rydb.

Locality #31, RC 106, 28 June. Open woods and meadows, on alluvium.

Geum macrophyllum Willd.

Locality #26, RC 157, 11 July. Open woods and meadows, on glacial moraine.

Luetkea pectinata (Pursh) Kuntze

Locality #2, RC 229, 28 July. Alpine tundra, on serpentine intrusive.

Potentilla diversifolia Lehm.

Locality #16, RC 32, 44a, 19 June; #25, WR 9096, 14 June; #26, RC 37e, 19 June; #28, RC 2, 16 June; #29, WR 9129, 15 June; #31, RC 107, 28 June; #36, RC 49a, 19 June; #38, WR 9024, 8 June. Alluvium, Bowser Formation, and coal beds, in meadows, lake shores, alpine tundra, and woods.

Potentilla fruticosa L.

Locality #5, RC 176, 22 July; #10, RC 125, 29 June; #26, RC 167, 11 July; #36, RC 54, 19 June. Lake shores, open woods, meadows, and heathlands, on glacial moraine and alluvium.

Potentilla hyparctica Malte

Locality #21, WR 9088a, 14 June; #22, WR 9132, 15 June; #34, WR 9035, 9 June. Alpine tundra, on slate and lavas.

Potentilla uniflora Ledeb.

Locality #16, RC 29, 19 June; #21, 9088, 14 June; #33, WR 9051, 10 June; #34, WR 9002, 9030, 8 June; #35, WR 9039a, 9 June. A dominant in alpine tundra, on Bowser Formation and lavas.

Rosa acicularis Lindl.

Locality #5, RC 174, 22 July; #6, RC 206, 26 July. Glacial moraine, in open woods.

Fig. 40. Stalk Lakes region collecting localities are on Jurassic Bowser siliceous conglomerate and sandstone (locality 12) and on alluvium and lake shore material associated with a landsile (locality 14), at the southwestern margin of the Spatsizi Plateau region.

FIG. 41. Coldfish Lake region between the Eaglenest Range, on the left, and Spatsizi Plateau, on the right. Locality 6 is at the campsite and is on glacial material, modified by lake margin deposits. The Eaglenest Range is held up by Jurassic volcanic rocks while the Spatsizi Plateau is held up largely by Tertiary Sustut Formation.

Rubus arcticus L.

Locality #26, RC 38, 19 June. Open woods, on glacial moraine.

Rubus idaeus L.

ssp. *melanolasius* (Dieck.) Focke

Locality #19, RC 133, 28 June. Open woods, on granite bedrock.

Rubus pedatus J. E. Smith

Locality #26, RC 37a, 19 June; do RC 145, 4 July. Open woods, on glacial moraine.

Rubus stellatus J. E. Smith

Locality #28, RC 1c, 16 June. Heathland, on alluvium.

Sanguisorba officinalis L.

Locality #2, RC 234, 28 July. Alpine tundra, on serpentine intrusive. This report represents a locality intermediate between populations in the Yukon and those to the south in British Columbia.

Sanugisorba stipulata Raf.

Locality #4, RC 189, 22 July; #6, RC 204a, 26 July; #26, RC 161, 11 July. Alluvium and glacial moraine in open woods.

Sibbaldia procumbens L.

Locality #29, WR 9135, 15 June; #36, RC 55, 19 June. Lake shores in open woods and alpine tundra on coal beds.

Sorbus scopulina Greene

Locality #26, WR 9080, 14 June; do RC 33, 19 June; do RC 72a, 77, 90, 25 June. Open woods and grassy slopes, on alluvium, glacial moraine, and talus.

Rubiaceae Madder Family

Galium boreale L.

Locality #5, RC 169, 22 July; #6, RC 190, 26 July, RC 120, 29 June; do RC 156, 11 July; #40, RC 102, 25 June. Open woods, meadows, and grassy slopes, on alluvium, moraine, and talus.

Salicaceae Willow Family

Populus balsamifera L.

Locality #1, RC 273, 13 Aug. River terrace gravels, in riparian woods.

Populus tremuloides Michx.

Locality #1, RC 267, 13 Aug.; #6, RC 260, 6 Aug.; #24, WR 9143, 15 June. River terraces, slopes, and open coniferous woodlands.

Salix arctica Pallas

Locality #3, RC 218, 27 July; #30, RC 15, 17 June; #37, WR 9012, 9013, 8 June; do, WR 9060, 13 June. Alpine tundra, on siliceous schist, Sustut Formation, and lavas.

Salix alaxensis Cov.

var. *longistylis* (Rydb.) Schneid.

Locality #1, RC 274, 274a, 13 Aug. River terrace gravels, in woods and thickets.

Salix barclayi Anderss.

Locality #26, WR 8986, 8988, 8998, 7 June; do WR 9082, 14 June; #32, WR 9045, 9046, 10 June; #64, RC 64, 19 June; #38, WR 9021, 9022, 9023, 8 June. Stream banks, lake shores, thickets, and meadows, on alluvium and moraine.

Salix barrattiana Hook.

Locality #32, WA 9043, 9044, 10 June; #38, WR 9026, 8 June. Stream banks and meadows, on alluvium and moraine.

Salix brachycarpa Nutt.

ssp. *brachycarpa*

Locality #38, WR 9028, 8 June. Stream banks and meadows, on alluvium.

Salix commutata Bebb.

Locality #36, RC 62, 19 June. Lake shore, in open woods.

Salix drummondiana Barr.

Locality #26, WR 8999, 7 June; do, WR 9086, 14 June; #36, RC 63, 19 June; #38, WR 9027, 8 June. Stream banks, lake shores, and meadows, on alluvium.

Salix glauca L.

Locality #6, RC 265, 6 Aug.; #25, WR 9144, 15 June; #26, WR 9064, 13 June; do WR 9081, 9085, 14 June; #29, WR 9140, 15 June. Lake shores, stream banks, open woods, heathlands, and tundra.

Salix monticola Bebb.

Locality #1, RC 272, 13 Aug. Stream terrace gravels.

Salix novae-angliae Anderss.

Locality #38, WR 9017, 8 June. Stream sides and meadows, on alluvium.

Salix reticulata L.

Locality #16, RC 24, 19 June; #35, WR 9040, 9 June; #37, WR 9007, 8 June. Alpine tundra, on Bowser and Sustut Formations, and on lavas.

Salix stolonifera Trautv.

Locality #37, WR 9006, 9006a, 8 June. Alpine tundra, on lavas.

Santalaceae Sandalwood Family

Geocaulon lividum (Richards.) Fern.

Locality #26, WR 8987, 7 June; do RC 95b, 25 June. Open woods, on alluvium and moraine.

Saxifragaceae Saxifrage Family

Heuchera glabra Willd.

Locality #25, WR 9125, 14 June. Grassy slope on Bowser Formation.

Leptarrhena pyroliflora (D. Don) R. Br.

Locality #26, RC 94, 95c, 25 June. Grassy slope, on talus.

Table 1. Summary of taxa collected in northern British Columbia.

	Lycopsida	Sphenopsida	Filicinia	Gymnospermae	Dicotyledonae	Monocotyledonae	Total
Families	2	1	1	1	35	5	45
Genera	2	1	2	4	89	14	112
Species	5	2	2	4	167	25	205
Subspecies	0	0	0	0	11	0	11
Varieties	0	0	0	0	35	0	35

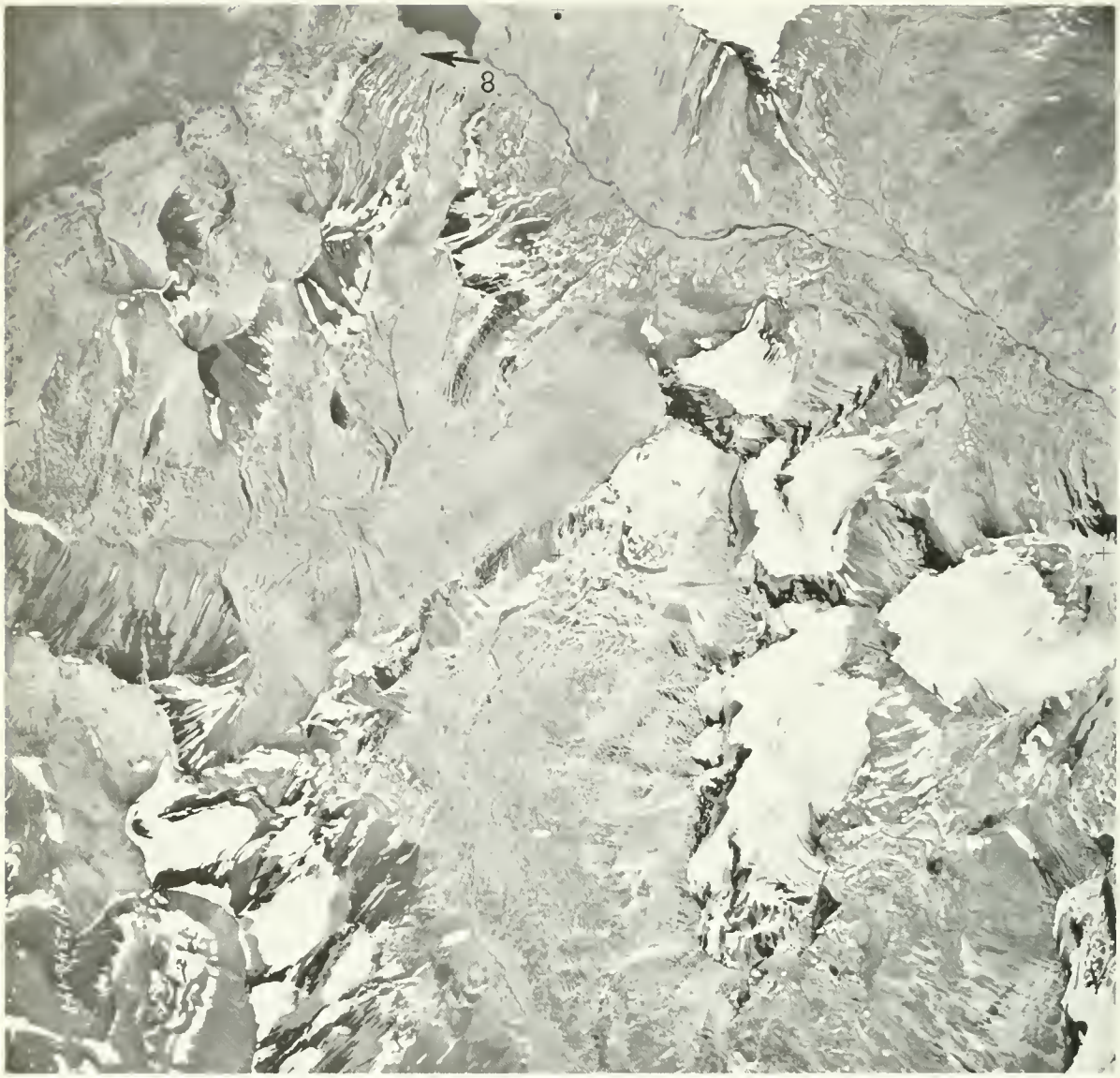


FIG. 42. Mt. Will region at the southern end of the Eaglenest Range. Locality 8, near Pass Lake, is in a low saddle carved in lower beds of the Bowser Formation. Mt. Will, between the three glaciers at right center is in massive Jurassic volcanic rocks.

Parnassia fimbriata Konig.

Locality ±2, RC 226, 28 July; #7, RC 250, 5 Aug. Alpine tundra, or serpentine intrusive and lavas.

Parnassia palustris L.

Locality #4, RC 188, 22 July. Glacial moraine, in open woods.

Ribes lacustre (Pers.) Poir.

Locality #26, WR 9066, 13 June. Glacial moraine, in open woods.

Ribes glandulosum Grauer

Locality ±25, WR 9108, 14 June. Grassy slope, on Bowser Formation.

Saxifraga ferruginea Grah.

Locality #12, RC 140, 30 June. Alpine tundra, on siliceous conglomerates.

Saxifraga flagellaris Willd.

var. *flagellaris*

Locality #9, RC 243, 1 Aug. Alpine tundra, on Bowser Formation.

Saxifraga lyallii Engler

Locality ±2, RC 235a, 28 July; #7, RC 251a, 5 Aug.; #8, RC 238b, 1 Aug. Alpine tundra, on serpentine, intrusive, Jurassic volcanics, and Bowser Formation.

Saxifraga nivalis L.

Locality #12, RC 99a, 27 June; #16, RC 26, 19 June. Alpine tundra, on barren shale slopes of Bowser Formation.

Saxifraga occidentalis Wats.

var. *rufidula* (Small) C. L. Hitchc.

Locality #25, WR 9109, 14 June. Grassy slope, on Bowser Formation.

Saxifraga oppositifolia L.

Locality #18, RC 131, 30 June; #34, WR 8979, 7 June; #37, WR 9008, 8 June. Alpine tundra, on marble, volcanic rocks, and lavas.

Saxifraga punctata L.

var. *porsildiana* (Calder & Savile) Welsh

Locality #12, RC 137a, 30 June. Alpine tundra, on siliceous conglomerates.

Saxifraga rivularis L.

var. *rivularis*

Locality #29, WR 9128a, 15 June. Alpine tundra, in Tertiary Sustut coal beds.

Saxifraga tricuspidata Rottb.

Locality #8, RC 239b, 1 Aug.; #19, RC 12, 13, 17 June; #25, WR 9112, 14 June; #37, WR 9014, 8 June. Alpine tundra, in lavas and Bowser talus and outwash, and on steep grassy slopes.

Scrophulariaceae Snapdragon Family

Castilleja miniata Dougl.

Locality #26, RC 35, 19 June; do RC 76, 25 June; #36, RC 53; 19 June. Open woods, meadows, and lake shores.

Castilleja unalaschcensis Hook.

Locality #2, RC 231, 28 July; #3, RC 211, 27 July; #6, RC 198, 26 July; #25, WR 9095, 14 June; #27, RC 117, 29 June. Open woods, meadows, grassy slopes, and alpine tundra.

Pedicularis bracteosa Benth. ex Hook.

Locality #25, WR 9117, 14 June; #26, RC 86, 25 June. Steep grassy slopes, on Bowser Formation. This is the northernmost known locality for this entity.

Pedicularis labradorica Wirsing

Locality #7, RC 252a, 5 Aug.; #26, RC 72c, 86a, 25 June. Open woods, meadows, and alpine tundra, on volcanic rocks and glacial moraine.

Pedicularis langsdorfii Fisch. ex Steven.

Locality #13, RC 100a, 27 June; #20, RC 19, 18 June. Alpine tundra.

Pedicularis sudetica Willd.

var. *gymnocephala* Trautv.

Locality #3, RC 211a, 27 July; #14, RC 9, 25 June; #29, WR 9127, 15 June; #36, RC 46, 19 June. Alpine tundra, open woods, and meadows, on micaceous schist, coal beds, and alluvium.

Penstemon procerus Dougl.

Locality #10, RC 126a, 29 June; #24, RC 149, 8 July; #31, RC 105, 28 June. Alluvium, on lake shores, and stream terraces.

Veronica serpyllifolia L.

var. *humifusa* (Dickson) Vahl

Locality #2, RC 231b, 28 July; #14, RC 60a, 25 June; #27, RC 121b, 29 June. Alpine tundra, on serpentine, intrusive, or along streams and lake shores on alluvium.

Veronica wormskjoldii

var. *wormskjoldii*

Locality #7, RC 249a, 5 Aug.; #8, RC 238a, 1 Aug.; #25, WR 9113, 1922a, 14 June. Alpine tundra and grassy slopes, on volcanic rocks and Bowser Formation.

Umbelliferae Carrot Family

Angelica lucida L.

Locality #26, WR 9087, 14 June; do RC 73, 25 June. Open woods on glacial moraine.

Heracleum lantum Michx.

Locality #25, WR 9106, 14 June. Steep, grassy, south-facing slopes.

Urticaceae Nettle Family

Urtica dioica L.

ssp. *gracilis* (Ait.) Selander

var. *lyalli* (Wats.) C. L. Hitchc.

Locality #25, WR 9124, 14 June. Steep, grassy, south-facing slope, on Bowser Formation.

Valerianaceae Valerian Family

Valeriana dioica L.

Locality #10, RC 126, 29 June; #31, RC 109, 28 June; #36, RC 52, 19 June. Wet meadows, river banks, and lake shores, on alluvium.

Valeriana sitchensis Bong.

Locality #3, RC 220, 27 July; #7, RC 251b, 5 Aug.; #25, WR 9093, 14 June; #26, RC 85, 25 June; do RC 164, 11 July. Grassy slopes and open woods, on alluvium, glacial moraine, and talus.

Violaceae Violet Family

Viola adunea Smith

Locality #25, WR 9114, 14 June; #26, WR 9054, 11 June; do RC 40, 19 June; #28, RC 1b, 6b, 16 June; #38, WR 9018, 8 June. Open woods, and meadows, on alluvium and glacial moraine.

Viola glabella Nutt.

Locality #26, WR 8995, 7 June. Open woods, on glacial moraine. This record represents an eastern extension of this entity from the more restricted coastal distribution previously known.

Viola renifolia Gray

var. *brainerdii* (Greene) Fern.

Locality #26, WR 9053, 11 June. Open woods, on glacial moraine.

PTEROPSIDA—ANGIOSPERMAE—MONOCOTYLEDONAE

Cyperaceae Sedge Family

Carex aquatilis Wahl.

Locality #26, RC 26, 25 June. Pond margin, on alluvium.

Carex deflexa Hornem.

Locality #38, WR 9019, 8 June. Dry, open woods, on alluvium.

Carex hoodii Boott?

Locality #25, WR 9094, 14 June. Steep, south-facing, grassy slope, on Bowser Formation. The specimen is somewhat immature and is difficult to ascribe positively to this entity.

Carex podocarpa R. Br.

Locality #12, RC 137c, 30 June; #15, RC 17, 18 June; #16, RC 26, 19 June; #20, RC 19a, 18 June; #29, WR 9136, 15 June; #34, WR 9034, 9 June. Alpine tundra, in lavas, coal beds, and siliceous conglomerates.

Carex praticola Rydb.

Locality #29, WR 9137, 15 June. Alpine tundra, on Tertiary Sustut coal beds.

Carex pyrenaica Wahl.

Locality #18, RC 128b, 30 June; #21, WR 9090a, 14 June; #22, WR 9058, 9058a, 12 June. Alpine tundra, on ridge crests, on marble, Bowser Formation, and slate.

Carex rossii Boott

Locality #25, WR 9124a, 14 June. Steep, south-facing, grassy slope, on Bowser Formation.

Carex vaginata Tausch

Locality #36, RC 48a, 19 June. Marshy lake shore.

Eriophorum angustifolium Honck.

Locality #26, RC 70, 25 June; do RC 151, 11 July. Pond margin.

Gramineae Grass Family

Calamagrostis purpurascens R. Br.

Locality #5, 177b, 27 July. Open woods, on glacial moraine.

Festuca altaica Trin.

Locality #12, RC 143, 30 June; #26, RC 66, 67, 25 June. Open woods, meadows, and grassy slopes, on Bowser Formation.

Hierochloe alpina (Sw.) R. & S.

Locality #12, RC 142a, 30 June; #29, WR 9142, 15 June. Alpine tundra, on Bowser Formation and coal beds.

Phleum alpinum L.

Locality #2, RC 230, 28 July. Alpine tundra, on serpentine intrusive.

Poa lanata Scribn.

Locality #12, RC 142, 30 June. Alpine tundra, on siliceous conglomerates of Bowser Formation.

Poa leptocoma Trin.

Locality #25, WR 9100, 14 June. Steep, south-facing, grassy slope, on Bowser Formation. This collection represents an eastward range extension for *P. leptocoma*.

Poa paucispicula Scribn. & Men.

Locality #22, WR 9059, 12 June. Alpine tundra, on slate.

Trisetum spicatum (L.) Richter

Locality #22, WR 9057, 12 June. Alpine tundra, on slate.

Vahlodea atropurpurea (Wahl.) Fries

Locality #26, RC 68, 25 June. Open woods, on glacial moraine.

Juncaceae Rush Family

Luzula confusa Lindeb.

Locality #41, RC 103a, 28 June. Alpine tundra, on alluvium.

Luzula parviflora (Ehrh.) Desv.

Locality #8, RC 240a, 1 Aug. Alpine lake shore, on alluvium.

Luzula spicata (L.) DC.

Locality #34, WR 8977, 7 June. Alpine fell field, on lavas.

Liliaceae Lily Family

Streptopus amplexifolius (L.) DC.

Locality #26, WR 9077, 14 June; do RC 153, 167a, 11 July. Open woods, on glacial moraine.

Veratrum eschscholtzii Gray

Locality #25, WR 9105, 14 June; #26, RC 155, 11 July. Meadows and steep, south-facing, grassy slopes, on Bowser Formation.

Orchidaceae Orchid Family

Listera cordata (L.) R. Br.

Locality #26, WR 9072, 14 June. Ground layer, in spruce woods, on glacial moraine.

Habenaria dilatata (Pursh) Hook.

Locality #25, WR 9118, 14 June; #26, RC 162, 11 July; do RC 83, 25 June. Marshy areas, along streams, and lakes, and in open grassy slopes, on Bowser Formation and glacial moraine.

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